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AUTHOR Conroy, David E.
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ABSTRACT

An investigation of student achievement gains in remedial Algebra I studied the relationship between achievement and the following variables: instructional technique (programed vs. conventional), student age, sex, and previous level of ability. An analysis of the equality of means of paired samples, made by a t-test, revealed that the variable of student age was significant, since older students experienced greater achievement gains. The variable of sex was not found to be related to significant differences in achievement and analysis indicated that when pre-test scores, age and sex were held constant, no significant difference in achievement resulted from the use of programed instruction versus conventional instructional techniques. These findings suggest that an in-depth study of the relationship between age and achievement be made in order to understand better its importance, and that research be undertaken to determine whether some combination of programed and conventional instructional techniques might maximize student achievement. (PB)

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THE EFFECTS OF AGE AND SEX UPON A COMPARISON BETWEEN
ACHIEVEMENT GAINS IN PROGRAMMED INSTRUCTION AND
CONVENTIONAL INSTRUCTION IN REMEDIAL ALGEBRA I
AT NORTHERN VIRGINIA COMMUNITY COLLEGE

by

David E. Conroy

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Faculty of the College of Arts and Sciences
of The American University
in Partial Fulfillment of
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of
Doctor of Education

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Signatures of Committee:

Chairman: Chalmers A. Gross

Stanley K. Smith
Dennis D. Miller

William M. W. [unclear]
Dean of the College

Date: August 9, 1971

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CHAPTER I

THE PROBLEM AND ITS SETTING

Introduction

One fundamental purpose of a community college is to organize its program of studies to meet the needs of the community that it serves. To achieve this goal, it seems reasonable that a regular analysis and evaluation of the curriculum is essential in order to satisfy the changing needs of the students. The specific aim of this study is to evaluate the effectiveness of the presentations of remedial Algebra I to the students in the Developmental Program at Northern Virginia Community College. Since two distinct methods of presentation have been used for several years in presenting the same subject matter of Algebra I to the students, it seemed vitally important that the appropriateness and effectiveness of these two presentations be evaluated. One method of presentation of remedial Algebra I at the College is the conventional lecture-discussion method. The other method of presentation is a programmed procedure in which a teacher is present to assist the student with any difficulties with the material.

Since both methods of presentation have been used for several years, it seemed pertinent that the effectiveness of these methods be evaluated through a comparative analysis. The

rationale for considering the necessity of this evaluation was based upon the possibility that certain students might achieve goals in remedial Algebra I more thoroughly under one method of instruction rather than under the other method of instruction. That is, perhaps older students could better achieve goals in remedial Algebra I using the programmed technique rather than being under the conventional technique. Or possibly, the factors of sex or previous ability would influence the success of a student using one method rather than the other method.

Thus, to provide the Department of Developmental Studies at Northern Virginia Community College with some guidance regarding the effectiveness of these two different approaches in presenting remedial Algebra I to the students, it was decided that an experimental study might reveal some guidelines that would be helpful in the implementation of the Algebra I curriculum. Possibly this experiment would reveal that one method is superior for all students over the other method. Or it might be concluded that one method is preferable for a certain age group, or a certain sex, or a combination of these two variables (age and sex). Therefore, it was decided that in studying the two methods of presentation (programmed versus conventional), the variables of age and sex would be given special emphasis in the experiment, to determine whether or not these variables would have any effect upon the students' achievement of Algebra in light of the two methods used.

Another possible outcome of this study is that the results also might provide more concrete direction for the student desiring to take remedial Algebra I in light of the two methods of presentation that the student is allowed to select. That is, counselors might be able to provide better guidance for the student requesting the course in remedial Algebra I. Possibly we would tell the middle-aged, female student that the anticipated better method for her to learn in Algebra I would be programmed instruction. Of course, the possibility of exceptions to the generalized results of this study would not be blindly ignored just to satisfy the statistical indications. However, the need for more guidance and analysis of the interaction of the variables of age and sex upon both methods of presentation is essential to the best application of the curriculum in Algebra I. It is expected that the results of this study will provide guidelines to the faculty members in Developmental Mathematics at Northern Virginia Community College so that they may more effectively advise the students concerning the best method of instruction in Algebra I. Thus, the student being taught by the most suitable method for him will achieve the objectives of the course in the shortest possible time.

The Setting for the Study

This study was conducted at Northern Virginia Community College at the Central and Eastern campuses during the summer

and fall quarters, 1970. The division involved in the study was the Developmental Studies Division which provides remedial courses in mathematics, English, and reading to those students who desire to attend college but are not adequately prepared to enter freshman-level, college courses.

In order to provide more insight regarding the college, the following was quoted from the College catalog:

The College is a two-year institution of higher education established under a state-wide system of Community Colleges in Virginia and serving the counties of Arlington, Fairfax, Loudoun, Prince William, and the cities of Alexandria, Falls Church, and Fairfax. These communities have a population of approximately 800,000 with a projected growth of 2,500,000 in the next 25 years.

The College operates on policies established by the State Board for Community Colleges and with the support and advice of a local Community College Advisory Board; and is financed primarily by State funds, supplemented by contributions from the seven local jurisdictions.¹

Historically, the College was originally established under the name of Northern Virginia Technical College through legislation by the 1964 State General Assembly, and the College has since experienced rapid growth and development. The College opened at Bailey's Crossroads in 1965 with an initial enrollment of 761 students and a staff and faculty of 46. Since its opening, the College has rapidly grown to an enrollment of approximately ten thousand students in the fall, 1970. In 1966, the General Assembly enacted legislation to

¹Catalog, Northern Virginia Community College, 1970-71,
p. 11.

include Northern Virginia Technical College in a new, state-wide system of community colleges. Since becoming a community college, a two-year University Parallel-College Transfer program has been added to its curriculum of occupational and technical education.

The following quotation from the catalog of the College will identify the general philosophy and purpose of the College.

Northern Virginia Community College is dedicated to the belief that each individual should be given a continuing opportunity for the development and extension of his skills and knowledge along with an opportunity to increase in awareness of his role and responsibility in society. The College is devoted to serving the educational needs of its community and assumes a responsibility for helping meet the requirements for trained manpower in its region through a cooperative effort with local industry, business, professions, and government.

Educational opportunities are provided for post-high school age youth and adults. These include high quality instructional programs at the associate degree level and at the foundation (preparatory) level. A strong guidance and counseling program, along with a number of other student services, is also provided to help each student make sound decisions regarding his occupational, educational, and personal goals and objectives.

Since the College is a division of the Virginia Community College System, its programs are approved by the State Board for Community Colleges and by the State Department of Community Colleges in Virginia. The associate degree programs of Northern Virginia Community College have been approved by

²Ibid., p. 12.

the State Council of Higher Education for Virginia, and the College is also accredited by the Southern Association of Colleges and Schools. The College is a comprehensive institution of higher education not extending more than two years beyond the high-school level.

The following statement indicated the admission requirements of the College:

Any person who has a high school diploma or the equivalent, or is 18 years of age, and in any case able to benefit from a program of instruction at Northern Virginia Community College may be admitted to the College as a regular student or as a special student. . . . Applicants will be accepted on a first-come, first-served basis subject to the quotas established for each curriculum.³

The significance of the open-door policy of Northern Virginia Community College is directly related to the Developmental Studies Program which provides remedial work in the subject areas of mathematics, English, and reading. Since many students, whether they receive a high-school diploma or not, are not prepared to perform college freshman work, the preparatory program provides, in many cases, a last and vital stepping stone by which the student can adequately become prepared for college-level work. However, the open-door policy not only includes the opportunity for students of quite varying academic preparations but also provides educational opportunities for a large age span of students; that is, adults already in a profession may return to school to

³Ibid., p. 15.

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improve their opportunities for advancement in their professions. Or women, whose children are now grown up, may return to obtain more education in a specific area so that they might return to a profession or begin a desired profession. Therefore, there is an opportunity for students of all academic preparations and all age levels to benefit from the educational opportunities offered at Northern Virginia Community College.

The specific philosophy of the Developmental Studies Division is to provide remedial instruction in the subject areas of English, mathematics, and reading using the best mode of presentation to meet the individual needs of the students. The concern of the Developmental Studies Division is to present the subject matter using various methods, thus providing the student the opportunity to achieve success in remedial work in the shortest possible time. Because of this great concern for the individual student, such methods of presentation as programmed instruction have become significant tools for learning in the Developmental Studies Program. This experimental study, analyzing the effectiveness of programmed instruction versus conventional instruction will not only be important in considering possible curriculum modifications, but also will be considered in reevaluating the philosophy of the Developmental Studies Division.

The organization of Northern Virginia Community College is based upon a multi-campus configuration. At the time of

this study in 1970, there were two campuses: the Central Campus which has five buildings and will be the hub of the other campuses when they are constructed, and the Eastern Campus which is in the temporary quarters at Bailey's Crossroads. The newly constructed building for the Eastern Campus in the vicinity of Bailey's Crossroads will be opened in September, 1972. Three other campuses are planned for completion in the near future: the Western Campus, the Northern Campus, and the Southern Campus. The president of the College is responsible for all five campuses, and a provost is assigned to each of these five campuses with the administrative responsibility for his own campus. Under the president is a staff of coordinators who assist the president of the College in meeting his responsibilities to the five campuses. Under each provost of each campus is the administrative staff and division coordinators for each of the divisions on his campus. The organization of the existing campuses is clearly indicated on the organization charts in Appendix D.

The Problem

The purpose of this study was to make an analysis and interpretation of the learning efficiency of programmed instruction versus the conventional presentation of remedial Algebra I at Northern Virginia Community College during the summer and fall quarters of 1970. This study was made in order to ascertain the effects of age, sex, and prior status

of achievement, measured by a pre-test, upon the learning efficiency of the students.

The Subproblems:

The subproblems for this study were the following:

1. To determine the present status of the students involved in this experiment by using the Cooperative Mathematics Test⁴ to measure the achievement of the students in mathematics. Data concerning the sex and age of the group also were obtained for analysis in this experiment.
2. To obtain achievement scores on an alternate form of the Cooperative Mathematics Test which was administered at the termination of this experiment.
3. To make an analysis of the results of the scores attained by the students prior to the experiment and at the termination of the experiment on the Cooperative Mathematics Test.
4. To make an interpretation of the results of the analysis in the third subproblem in order to determine the weights of the factors of age and sex upon the outcome of this experiment.

The Delimitations:

The time period for this study was limited to the summer and fall quarters of 1970 at Northern Virginia

⁴Cooperative Mathematics Tests--Algebra I--Forms A and B (Princeton, New Jersey: Cooperative Test Division, Educational Testing Service, 1962).

Community College.

The teaching materials for this study were limited to William Wootan and Irving Drooyan's Intermediate Algebra--Second Alternate Edition⁵ and Alwin and Hackworth's Algebra--Programmed.⁶

This study did not investigate the effects of various techniques of programmed instruction beyond that which was necessary for clarity.

Only students between the ages of sixteen and fifty-three were included in this experiment.

This study did not consider any students who have previously had college mathematics courses.

Both methods of presentation were directed towards emphasis upon the same topics in both courses.

The data obtained from the experimental group of students using programmed instruction were limited to those students who started the course in Algebra I at the beginning of either the summer or fall quarters, 1970, and completed the programmed course by the end of the same quarter.

Definitions of Terms

Programmed instruction. Programmed instruction is a logical sequence of operations performed primarily by student

⁵William Wootan and Irving Drooyan, Intermediate Algebra--Second Alternate Edition (Belmont, California: Wadsworth Publishing Company, Inc., 1968).

⁶Robert R. Alwin and Robert D. Hackworth, Algebra--Programmed (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969).

self-direction and self-motivation in order to achieve the goals of the course. In the present study a teacher was always available in the classroom to provide assistance to those students having difficulty achieving specific concepts in remedial Algebra I. The time span in which students completed the entire programmed Algebra I course at Northern Virginia Community College ranged from five weeks to thirty weeks. The students using the prescribed, programmed, Algebra I text progressed through sequential, non-branching frames without any involvement of a computer.

Conventional instruction. Conventional instruction in remedial Algebra I is a logical and sequential presentation of algebraic concepts through a teacher's efforts to assist students in attaining sufficient self-motivation in order to achieve the goals of the course. In the present study a workbook entitled Study Guide for Intermediate Algebra--Second Alternate Edition,⁷ which was written specifically for the prescribed conventional text, provided students sufficient problems in order to comprehend new concepts presented by the teacher. The conventional course in remedial Algebra I at Northern Virginia Community College was presented during one quarter.

⁷Bernard Feldman, Study Guide for Intermediate Algebra--Second Alternate Edition (Belmont, California: Wadsworth Publishing Company, Inc., 1969).

Mathematical concepts. Mathematical concepts shall be defined as those qualified relationships of equality and inequality which can be formulated in order to evaluate the validity of logical sentences.⁸

Learning efficiency. Learning efficiency shall be defined as a relative measure which was determined by the differences in Cooperative Mathematics Test scores attained by the students at the beginning and at the end of the experiment.

Flexibility. Flexibility in programmed instruction shall refer to that process by which the student may modify the logical sequences of the course for the purposes of review or advancement over concepts already achieved.

Old students. Old students in this study shall refer to those students who rank in the top-third, age group of all students in the experiment.

Young students. Young students in this study shall refer to those students who rank in the bottom-third, age group of all students in the experiment.

The Assumptions

The study was based on the assumptions listed below:

1. The first assumption was that Cooperative Mathematics Test scores were a valid basis for the assessment of

⁸Statement by Bernard Mandel, personal interview, February 26, 1970.

achievement of the groups involved in this experiment.

2. The second assumption was that programmed teaching materials and lecture-course-teaching material used at Northern Virginia Community College were similar in content.

3. The third assumption was that the scores attained by the students on the Cooperative Mathematics Test would reflect their understanding of Algebra I.

The Hypotheses

The hypotheses which were tested to evaluate the third subproblem, which was to make an analysis of the results of the scores attained by the students prior to the experiment and at the termination of the experiment on the Cooperative Mathematics Test, were the following:

1. The study hypothesized that there would be no significant difference in level of achievement between older and younger students under conventional presentations.

2. The study hypothesized that there would be no significant difference in level of achievement between older and younger students using programmed instruction.

3. The study hypothesized that there would be no significant difference in achievement between paired male and female students in the same age class.

4. The study hypothesized that there would be no significant difference in achievement between the students in programmed instruction and students in conventional instruction

when the students were paired according to the independent variables of age and sex to eliminate the effects of these variables.

The Importance of the Study

The study was important for several reasons. In the light of the sparsity of significant research in the area of programmed instruction at the community-college level, it was hoped that this study would serve as a contribution which would permit more optimal implementations of the programmed instruction technique at this level in the future. As revealed in the review of related literature, there was a limited number of comparative studies at the community-college level between programmed instruction and conventional instruction in Algebra I. Conclusions from these studies may have been drawn which were not significant or meaningful in terms of determining when one method was better to be employed over another method. Further, there was an extreme lack of comparative studies of these two methods of instruction that have been performed at the community-college level in remedial Algebra I.

This study also was important since it could further assist the coordinators of the Developmental Programs at Northern Virginia Community College in performing curriculum modifications in order to best meet the needs of the students. The results of this study could assist in counseling new students entering the Developmental Program so that they might achieve the maximum possible knowledge of remedial Algebra I.

in the shortest possible time with the important factors of ease of learning and enjoyment of subject matter considered. Therefore, this study could possibly contribute guidelines when considering the adaptability of individual students to these two modes of instruction for optimal learning.

The study also could serve as a model upon which future statistical analyses of different classroom presentations may be based. It had already been decided by the Coordinator of the Developmental Studies Division at the Central Campus of Northern Virginia Community College that the statistical model used in this study would be used on a regular yearly basis to evaluate the effectiveness of the methods of presenting remedial Algebra I. Of course, possible modifications of the statistical model in this study were considered in light of the changing needs of the students that could affect the use of this model in the future.

Another important reason for this study was that the results might be meaningful and applicable to other community colleges throughout the country that provide courses in remedial mathematics. Although the results of this present study may not totally apply to another community-college program, it may be possible that some of the techniques used or the indications from the results of this study could be of some assistance in implementing a program or modifying an existent program in remedial Algebra I.

The Organization of the Remainder of the Study

In retrospect, the present chapter has indicated the actual problem of this study and the environment in which the study was performed. The subproblems along with the delimitations, definitions, assumptions, and hypotheses were considered. In presenting the setting for this study, a description of the subjects involved was given, accompanied by a description of the environment of the Northern Virginia Community College, which included such topics as the philosophy, organization, and administrative plan of the college. In concluding Chapter I, a brief summary of the importance of the present study was provided.

In Chapter II an analysis of the methodology is presented, including the research design that would be utilized in performing the experiment.

In Chapter III, which provides a review of the related literature, a classical study in the field of the present study is investigated and analyzed. Next, several studies related to this study are considered along with some research that indicates the conflicting results that seem to be frequently prevalent in this field of programmed instruction in mathematics. Finally, the literature that is similar to the present study, especially in terms of methodology, is described and related to the research of this study. In concluding Chapter III, a brief summary of the related literature in light of its relevance to the present study is presented.

In Chapter IV the findings related to each subproblem are indicated; however, the emphasis on findings in the present study is related mainly to the third subproblem with which all the hypotheses are associated. The results of all tests of hypotheses are presented in detail with clarification provided through the use of tables and diagrams. Specific emphasis is given to the involvement of the independent variables of age and sex as these variables might modify the effectiveness of the programmed and conventional modes of presenting remedial Algebra I. When concluding Chapter IV, several summarizing statements concerning the overall results of all the tests of the hypotheses are included.

The last chapter, Chapter V, will include a summary, and some conclusions and recommendations concerning the results of Chapter IV as these results relate to the existent research that was described in Chapter III, and to the Developmental Studies Program at Northern Virginia Community College as described in Chapter I. Included within the recommendations is a concern about future experimentation and research pertinent to the research and experimentation involved in the present study.

CHAPTER II

THE METHODOLOGY

The method used in this study was the experimental method. The subjects involved in this experiment were students taking remedial Algebra I during the summer and fall quarters, 1970, in the Developmental Mathematics Programs at the Central and Eastern Campuses of the College. Since the independent variables of age and sex were considered in this experiment along with the pre-test score attained by each student, both male and female students involved in this experiment covered a large span of ages, in order to evaluate the effects of age and sex. To provide further clarification regarding the subjects included in this experiment, Table I shows the number of students in the control group (conventional presentation) and the number of students in the experimental group (programmed instruction). Further information is provided in Table I concerning the mean pre-test score for each group and the mean age for each group along with totals for sex, and overall means for age and pre-test scores.

In organizing the experimental and control groups for this study, particular attention was consistently given to equality in the pairing process. When all the data were

TABLE 1
CHARACTERISTICS OF GROUPS

Students	Experimental group	Control group	Totals
Male	40	130	170
Female	27	63	90
Totals	67	193	260
Mean pre-test scores	14.94	14.1968	14.388
Mean age	15.47	15.70	15.646

obtained, the following specific factors were considered in order that the results would be as valid as possible. No students were involved in the actual comparison if they had any previous college mathematics courses. This constraint included even those students who had previously taken remedial mathematics courses at Northern Virginia Community College. Thus, every student involved in the experiment had never had college mathematics before entering the remedial Algebra I courses that were being tested in this experiment. The fact that some students had taken Algebra I in high school was not considered significantly relevant to the experiment. This assumption seemed valid because either the time period since the students had taken high-school Algebra was quite long, or the students who had just been graduated from high school and were in remedial Algebra I at the College had done very poorly in high-school Algebra.

Another factor considered important in organizing the experimental group and control group for this study in light of the independent variable of age was the actual age span of the students involved in the experiment. In the process of experimental organization, all attempts were made to incorporate groups of students with the greatest age span possible in the experimental design. To further assist in obtaining the greatest possible age span of students, both day and evening remedial Algebra I students were involved in the experiment.

To eliminate as much as possible the effects of particular teacher methodologies upon the outcomes of the experiment,

as many teachers as possible were requested to participate in the study. The names at the bottom of the memoranda in Appendix B will attest to the thirteen teachers involved in the presentation of remedial Algebra I in this study. Thus, it was assumed that the effects of different teaching techniques used by individual teachers upon the results of the study were sufficiently eliminated by the number of teachers involved in the experiment so that the individual teaching methods did not bias the experimental results.

Another major factor considered when making the initial arrangements for the study was the actual comparability of the subject matter being presented. It was extremely important that the topics presented in Alvin and Hackworth's Algebra--Programmed be sufficiently similar to the topics presented in the first five chapters of Wootton and Drooyan's Intermediate Algebra--Second Alternate Edition; otherwise, the achievement gains in conventional instruction would not be comparable due to significant differences in the topics presented in both modes of presentation. To verify the similarity sufficient for purposes of the study, several of the faculty members involved in the experiment were requested to analyze the Algebra I materials used in programmed instruction and conventional instruction to ascertain whether or not any significant differences existed in the topics presented in both forms of instruction. After confirmation from these faculty members that the study materials were

sufficiently similar for purposes of comparison, it was considered viable to proceed with the actual experiment.¹

Another factor considered in organizing the experimental group and control group was the number of students that would be actually involved in the experimental analysis. The number of subjects involved in an experiment is extremely important since as the sample size increases the acceptance and validity of the statistical results increases. However, in the process of organizing this experiment a certain number of students had to be eliminated from the experiment for one of the several following reasons:

1. Those students who had registered for the course but had dropped the course⁵ at some time during the quarter were eliminated from the experiment for the purposes of obtaining usable data.

2. Some of those students who started the lecture course were allowed to change to the program course because it was believed that they could achieve more success under the programmed method. Therefore, these students were eliminated from the experiment since they had received instruction in remedial Algebra I under the two methods being studied.

3. Those students who registered during late registration were eliminated from the experiment since it was believed that they were possibly lacking the subject matter that was

¹Statement by Altus Prince and Sharon Horyna, personal interview, May, 1970.

presented at the beginning of the course. To have included these students would possibly have caused the statistical results to be less accurate.

4. Since a student in programmed instruction proceeds at his own individual pace, there were those students in the experiment who did not complete the Programmed Algebra I course. Thus, these students could not be validly included in the experimental comparison since the experiment is based upon a comparison of achievement gains for students attaining all of Algebra I in one quarter under both methods of presentation.

The instruments upon which the experimental comparison was based were the Cooperative Mathematics Tests--Algebra I--Forms A and B.² These tests were considered the best instruments to measure achievement gain because of the relationship of the test items to the topics presented under both presentations. These tests were also considered a valid measure of achievement because of their standardization.

According to Paul Bloomers who evaluates the Cooperative Mathematics Test--Algebra I in Buros' Sixth Mental Measurements Yearbook,³ the test is an excellent instrument for a pre-test, post-test evaluation of an Algebra I course.

²Cooperative Mathematics Tests--Algebra I--Forms A and B (Princeton, New Jersey: Cooperative Test Division, Educational Testing Service, 1962).

³Oscar K. Buros (ed.), Sixth Mental Measurements Yearbook (Highland Park, New Jersey: The Gryphon Press, 1965).

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Bloomers believed the test is also suitable for evaluating Algebra I whether it was taught from a modern or traditional textbook. The only major weakness of the test involves the limited normative data available, even though the small population from which the data were obtained was an excellent cross section of the United States. Bloomers summarized his remarks in stating ". . . this end-of-course Algebra test may be said to be of excellent quality. The test appears to be reasonably valid for students whose training in Algebra was either of the traditional or modern type."⁴

A final reason that this test was used as the measure of achievement gain was due to the superb cooperation of the Educational Testing Service in Princeton, New Jersey, who gave permission to duplicate its test for the purpose of performing the experiment in this study. Correspondence related to this communication with the Educational Testing Service can be found in Appendix C. However, concurrent with permission to use the Cooperative Mathematics Test was the agreement that neither the A Form nor the B Form of the test used in this experiment would be included in this dissertation in order to maintain the security of their examinations.

The devices or material used in performing the experiment consisted of several items. One device was an information form which was constructed to ascertain the age, sex, type of instruction, years since high school, and previous mathematics

⁴Ibid., p. 595.

courses taken during high school or college (see Appendix A). The form was filled out by the students involved in the experiment at the time the pre-test was administered to the students.

Another set of materials used in this study was the memoranda distributed to the teachers who participated in the experiment (see Appendix B). These memoranda indicated to each teacher how the pre-test or post-test was to be administered and how the form (Appendix A) was to be filled out by the students. One important point emphasized in the memoranda to the teachers was that the existence of an on-going experiment was not to be divulged to the students involved in the experiment. It was assumed that if the students were not aware of the experiment, the Hawthorne effect could be sufficiently avoided so as not to affect the results of the experiment. Another major reason for the memoranda is that they reminded the teachers of the experiment, so that they could arrange their class schedules to include the administration of the pre-test and post-test.

To assist in performing the statistical analysis, and to provide data summaries, permission was granted by Northern Virginia Community College to utilize their computer facilities at the Central Campus. The computer used in analyzing the data and performing the statistical tests was the Honeywell 1250 computer. A copy of the form granting access to the computer to provide assistance in performing the experiment can be found in Appendix E.

Since the research design is experimental in nature, the initial step was to search the related literature to ascertain the need for the experiment. Chapter III of this study presents the paucity of experimental research concerning various methodologies of presenting remedial Algebra I at the community-college level. Thus, to alleviate partially the lack of research on the topic of this study, an experimental design was used to analyze the implementations of the programmed and conventional methods of presenting remedial Algebra I. Specifically, to perform this comparison or contrast, pairs were formed based upon the independent variables of age, sex, and the pre-test scores. Next an analysis of the equality of the means utilizing the t-test for paired samples was employed for all statistical comparisons or contrasts in this study. An explanation for the formula can be seen in Appendix F.

In Dixon and Massey's Introduction to Statistical Analysis, it is emphasized that in many experiments that take samples from two populations there exist certain extraneous factors that result in an apparent significance, whereas, in actuality the effects being measured have no difference or significance.⁵ For example, as in this present study, Dixon and Massey suggest that it might be desired to analyze two different methods of teaching a subject to determine which

⁵Wilfred J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (New York: McGraw-Hill Book Company, 1957), p. 124.

method is better. However, the greater effectiveness of one method over the other might not be revealed if the ability of the students involved is not considered. That is, one group of students being taught by one method may possess greater ability with the subject under consideration than the group of students under the other method. Therefore, the method used with students having greater ability will apparently seem to be the better method; whereas, the greater effectiveness of one method over the other could well be due to the extraneous factor of the ability of the students involved. Thus, if the two population samples can be paired on as many factors as possible except for that factor which is to be measured, a majority of the extraneous factors can be eliminated, and the significance of the factor being tested can be more readily determined. As Dixon and Massey state concerning this "method of paired comparisons":

One design for experiments which sometimes overcomes part of the above difficulty is the device of taking the observations in pairs. We try to make sure that the two members of any pair are alike in all respects except that which we are trying to measure. This is an ideal, of course, and we are limited by the availability of pairs which are similar and by our ability to choose similar pairs.⁶

Thus, in performing an experiment which uses the "method of paired comparisons" an attempt is made to obtain as many pairs as are possibly available, in order to increase the reliability of the test of equality of means. However, the

⁶Ibid., p. 125.

desire for a sizeable number of pairs should not allow any sacrifice in accuracy in forming pairs that are similar. To become haphazard or careless concerning the similarity of the pairs in preference to a large sample size would defeat the basic concept of a "paired comparison." The importance of a "paired comparison" as a measure of a specific factor is obvious in the statement by George W. Snedecor and William G. Cochran that "the objective of pairing is to increase the precision of the comparison of the two procedures."⁷ Of course, certain extraneous factors may affect some individuals, but it is assumed that they affect each member of any one pair in exactly the same manner. It also is assumed that the effect is essentially one of increasing (or decreasing) each of the means by some constant which will be eliminated when the difference between achievement gains for the members of each pair is calculated.⁸

Another advantage in using "paired comparisons" is that the variances of the two population samples do not have to be assumed equivalent as would be the case in an analysis of variance. It also is not necessary to assume that the observations that are paired correspond to a process of individual random selection to maintain independence of the variable under analysis, since the fact that the pairs are

⁷George W. Snedecor and William G. Cochran, Statistical Methods (Ames, Iowa: The Iowa State University Press, 1967), p. 67.

⁸Dixon and Massey, op. cit., p. 125.

meticulously selected obviously eliminates randomness.

A final consideration is the loss of information if there are actually no extraneous effects that warrant a "paired comparison." According to Dixon and Massey, this loss of information could cause an increase in the Type II error (accepting the hypothesis when it is false), but this increase is slight if the sample size is greater than ten.⁹

The factor of sample size is extremely important since the reliability of any conclusion is directly related to the size of the population samples tested. In this study the minimum limit of ten for the sample was maintained without any sacrifice in the precision of pairing as can be verified by observing the results of the experiment in Chapter IV.

Thus, the use of the t-test for equality of means, using "paired samples," was used to test each of the stated hypotheses. The method of "paired comparisons" was selected since the extraneous factors of age and sex were considered to be relevant in light of an analysis of the effectiveness of the programmed method of teaching Algebra I versus the conventional method.

⁹Ibid.

CHAPTER III

THE REVIEW OF THE RELATED LITERATURE

Introduction and Framework

Since the initial implementation of programmed instruction in algebra in the early 1960's, there has been great concern but little substantial or conclusive results from the use of this technique. In the case of this study, special concern is to be directed towards the results of comparing programmed instruction versus conventional techniques in presenting a course in remedial Algebra I. Comparisons of these two approaches have been performed, but no significant results were obtained. Schramm indicated this paucity of significant or conclusive results concerning comparative analyses of programmed instruction versus conventional instruction when he stated ". . . that of the thirty-six pieces of research comparing programmed instruction with conventional classroom instruction, half showed no significant difference."¹ In continuing the thought, he indicated that in numerous experiments no significant differences existed simply because the programs employed were too short or the sample was too small or the

¹Wilbur Schramm, The Research on Programmed Instruction: An Annotated Bibliography (Stanford, California: Institute for Communication Research, Stanford University, 1962), p. 10.

measuring instruments were too dull to measure any differences that may have existed!²

Thus, there seem to be very few studies that might contribute substantially to a meaningful use of programmed materials. It was pointed out in a conclusive remark by Schramm that "others attempting to delve into the research reported to date have found the same lack of information."³ Many of the results of comparative analyses researched for this study reveal basic statistical results lacking any essential information upon which some substantial and meaningful conclusions could be based. There seem to be no definite generalizations that can be ascribed to similar studies upon which the decision to use programmed instruction can be weighed. The aims of these studies seem to be stereotyped in the light of specific groups under very specific circumstances. What would seem more feasible would be just one conclusion from a study that might be considered seriously by most of the people in the field of programmed instruction as an idea that truly contributes to the ultimate decisions concerning a performance of one form of instruction in contrast to another form.

A survey of the literature revealed very few studies based upon experimental comparisons of programmed instruction versus conventional instruction at the college level. Most of the studies were concerned with comparisons at the high-

²Ibid.

³Ibid.

school level, as will be apparent in the analysis of the following studies. However, the present study will employ some of the experimental techniques used at the high-school level in analyzing the use of programmed instruction with remedial mathematics students at the community-college level. Thus, it is the desire of the author of the present study to help fill the vacuum of limited studies of this nature at the college level and contribute some results that might be applicable to similar collegiate situations.

Since both basic texts used in the comparative analysis in this experimental study were of such recent publication, it was difficult to find any similar studies that performed comparisons using the same texts as a base. This situation will preclude the possibility of repetition of experiments using the same basic texts, which is one keynote of substantiating the results of experimental comparisons; however, it would seem reasonable that this factor is compensated for sufficiently when one considers the significance of a comparative analysis on two very recent but different approaches in presenting the same topics in Algebra I. Thus, due to the employment of recently published texts in the comparison, it would seem reasonable that the results of this completed study will be a relatively sound indication of the state of the art of programmed instruction.

A Classical Study in the Field

Because of the paucity of significant research in comparative analyses of programmed instruction versus conventional instruction in Algebra I, the emphasis of this section will be limited to a study considered to be outstanding in the field of programmed instruction. The present study is concerned with the interaction of the three independent variables of age, sex, and prior achievement as they affect the dependent variable of achievement gain (or loss) in programmed instruction and conventional instruction. A study performed by John E. Coulson and Harry F. Silberman was deemed to be a classical study for the present research.⁴ Lewis D. Eigen very pointedly emphasized the importance of the Coulson-Silberman study when he stated "one study which is a good example of investigation that programmed instruction should check is a three-variable study by Silberman and Coulson."⁵ The three independent variables in Silberman and Coulson's study were student response made, size of steps between successive items, and the sequencing procedure. Eigen continued, in his appraisal of their study, saying that "while this study did not answer any

⁴John E. Coulson and Harry F. Silberman, Results on an Initial Experiment in Automated Teaching: Teaching Machines and Programmed Learning, eds. A. A. Lumsdaine and R. Glaser, Vol. 11 (Washington, D.C.: National Educational Association, 1960), pp. 452-68.

⁵Lewis D. Eigen, "Problem of Research in Programmed Instruction," Audio-Visual Review, XIII (Spring, 1965), 42.

branching questions, it was a landmark of methodology in programmed research."⁶

Eigen's statement concerning Coulson and Silberman's study was extremely accurate in the sense that the methodology used in performing their study seemed more detailed and precise than the studies that will be considered in the following reviews of related literature. The actual purpose and results of the study by Coulson and Silberman were not directly related to the present study, but the excellent techniques used in their statistical analysis warranted special consideration. Coulson and Silberman were concerned with a comparison of various techniques of employing teaching machines to educate students as opposed to conventional classroom methods; however, their major concern was to determine whether or not students could learn at all from teaching machines. It was hypothesized that students using the branching procedure of programmed instruction would learn as well as students not using branching instruction and the students using the branching procedure would also learn in a shorter time.⁷ The Coulson-Silberman experiment had three phases: (1) a period in which the students were given practice exercises on various teaching machines, (2) a criterion quiz which was administered immediately after the preparation or study period, and (3) the same criterion quiz was given three

⁶Ibid. ⁷Coulson and Silberman, op. cit., p. 454.

weeks after the experiment was over to measure retention. It would seem that the use of the same criterion test to measure retention should possibly be questioned; and although the programmed instruction was only being compared to the conventional instruction for the purpose of determining whether or not learning takes place under programmed instruction, it would seem reasonable that the subject material would, at least, be similar. Yet, the authors of the study readily admit to the fact that the subject material taught using programmed teaching machines was not closely related to the material taught in the conventional classroom.⁸

The pre-test used to match the groups of students who would be using various techniques of educating under different teaching machines was not at all related to the criterion test administered at the end of the experiment. Thus, the purpose was not to ascertain achievement in a specific subject area but rather to determine whether or not learning can result through the use of teaching machines based upon similar student populations. The importance of Coulson and Silberman's study in relation to the present study lies in their methodology. Their use of analysis of covariance and the coefficient of correlation to examine the data involved with the experiment provided initiative to consider these methods or other methods to analyze the variance in the present study.

⁸Ibid., p. 455.

Since the pre-test and post-test of the present study were extremely important measures upon which the entire study relied, it seemed most necessary that not only the test used be standardized and appropriate to measure the achievement of students, but that the test items be constructed so that the students from the experimental and control groups would have a sufficiently equal chance of attaining the best possible score. In Coulson and Silberman's study it was found that the students who used the teaching machines in their course did significantly better on the multiple-choice items of the criterion test when it was readministered to test retention three weeks after the termination of the study period. The authors of the study seemed somewhat puzzled by this occurrence of a significant difference on the multiple-choice items as was reflected in their statement that "... it is difficult to explain why a similar improvement did not occur on the constructed response (fill-in) subtest"⁹ which was also a part of the criterion test. The impact on the present study of these differences in results on multiple-choice items obtained by Coulson and Silberman on their criterion test warrants special consideration since the Cooperative Mathematics Test used in the present study utilized the multiple-choice technique throughout both forms of the tests that will be used as a pre-test and post-test. Possibly, as hypothesized by Coulson and Silberman, the students under programmed

⁹Ibid., p. 461.

instruction became acquainted with this type of test or possibly the method using the teaching machines could have caused the improvement. The significance of the mean improvement of .8 points mean improvement from 11.6 points to 12.4 points was not disregarded in the present study; however, the time lapse between the administration of the pre-test and post-test of approximately ten weeks in the present study, as opposed to three weeks in the study performed by Coulson and Silberman, may have eliminated this factor of mean gain on multiple-choice items for students taught under programmed materials. Likewise the use of programmed texts in the present study, as opposed to the use of teaching machines in Coulson and Silberman's study which employed multiple-choice techniques in the process of educating, may also have eliminated this factor of mean gain on multiple-choice items on the post-test. The keynote of Coulson and Silberman's study, in relation to the present study, was the fact that some of the techniques they employed in performing their experiment were also used in the present study; and the possibility of biased results due to the use of multiple-choice items on the pre-test and post-test in the present study were closely scrutinized throughout the duration of the experiment. Likewise, their use of analysis of covariance as a statistic to analyze the interaction of independent and dependent variables in their experiment was considered.

Recent Studies and Literature Related to this Study

In this survey of related studies on programmed instruction versus conventional presentations, the evidence of conflicting results should be apparent. In an abstract of his dissertation, D. F. Devine indicated that the reports on programmed instruction showed conflicting evidence and opinion regarding actual learning of subject matter involved, and a lack of testing of attitude development.¹⁰ In many recent studies, there seemed to be a need to de-emphasize just the statistical results in favor of indicating some substantial conclusions. L. W. Smith, in his article on programmed instruction, indicated that "programmed materials, now in what is most aptly described as the 'Model T Stage,' will undergo a wide variety of uses and abuses."¹¹ One keynote of this statement seemed to be the abuse which was being made of the techniques of programmed instruction and its evaluation as a method of instructing students. Schramm supported this statement by Smith when he said that the numerous experiments on programmed instruction that supported the hypothesis that no significant difference existed between the two methods of instruction may, indeed, prove that no significant difference

¹⁰Donald F. Devine, "Student Attitudes and Achievement: A Comparison between the Effects of Programmed Instruction and Conventional Classroom Approach in Teaching Algebra I at Rich Township High Schools," Dissertation Abstracts, XXVIII (1967), 535-A.

¹¹Leander W. Smith, "The Use and Abuse of Programmed Instruction," Mathematics Teacher, LVIII (December, 1965), 703.

actually existed; but the suspicion arose that in many cases the programs were too short, the sample too small, the measuring instrument too dull to pick up differences if they existed.¹² Thus, as should be apparent in the related studies that follow, there was a lack of any truly conclusive evidence, which simply served to indicate the extreme need for more experimental research especially in the case of programmed instruction versus conventional instruction. Eigen, in his article on programmed instruction, indicated that even a casual review of the literature revealed great conflicts between the experimental outcomes and theoretical predictions.¹³ Yet, the need for further research must be qualified in the sense that the purpose of any new experiment should be diverted toward meaningful and significant results and not persevere in the repetitive, insignificant results that have, till this time, been the case. As Eigen said, "while the lack of research is always to be deplored, more research of the same type that has already been done in the area of programmed instruction would probably do little more than increase the conflicting evidence and resulting confusion."¹⁴

In an optimistic note concerning the research in the area of programmed instruction, Briggs stated that ". . . there

¹²Wilbur Schramm, The Research on Programmed Instruction: An Annotated Bibliography (Stanford, California: Institute for Communication Research, Stanford University, 1962), p. 11.

¹³Eigen, op. cit., p. 43.

¹⁴Ibid.

is some recent indication that research in programmed instruction is merging with the mainstream of educational research.¹⁵ However, as Briggs did not realize, the results of these recent studies did not lend themselves to significant conclusions in the area of programmed instruction. Briggs believed that the trend from a concern about the size of step, mode of response, and item sequence to a concern about personality, intellectual, and emotional variables was a refinement of the research in favor of more significant results. The trend may exist, but the need for less conflicting and more significant results, if they exist, becomes more urgent and vital as the applications of programmed instruction increase.

To further support these previous statements concerning the state of the art of programmed instruction versus conventional instruction, several abstracts and reviews of studies will be analyzed briefly. Special emphasis should be afforded the results of these studies in order that one may become more attuned to the actual and very desperate need for more substantial and meaningful results when comparing or contrasting programmed instruction with conventional instruction.

The first comparative study of programmed instruction versus conventional instruction to be considered in this

¹⁵L. J. Briggs, "Learner Variables and Educational Media," Review of Educational Research, XXVIII (April, 1968), 165.

review of related literature was performed by J. I. Moses¹⁶ at the high-school level in Algebra I. He analyzed the differential in achievement based upon the two methods of classroom presentation. The findings of the study by Moses indicated that students with academic ability could progress at a faster rate in programmed instruction and achieve a higher level of mastery of the subject.¹⁷ He also found no advantages in programmed instruction for the slow learner. The general conclusion he drew, in light of the group as a whole, was that from the standpoint of the mastery of the course by all participants, there was no advantage to either method.¹⁸ Thus, the first study demonstrated the apparent fact that no significant difference seems to be the case in most comparative analyses. This is not to ignore, though, the fact that although there was no significant difference, there was at least a leveling tendency towards equality between both methods of presentation; and it can be concluded from Moses' study that at least the method of programmed instruction does achieve a fairly respectable level of presenting material to students. It should be pointed out that according to the date of publication of this study, it was performed during the initial phases of programmed instruction, and as

¹⁶John I. Moses, "A Comparison of the Results of Achievement with Programmed Learning and Traditional Classroom Techniques in First Year Algebra at Spring Branch Junior High School," Dissertation Abstracts, XXIII (1962-63), 1559.

¹⁷Ibid.

¹⁸Ibid.

indicated in an earlier statement, possibly more precise measuring tools would have revealed differences that were not apparent at the time when the study was performed. Moses' use of a Cooperative Mathematics Test, though, provided direction in the determination of the measuring instrument to be implemented in the present study. However, the present study differed from Moses' study in that the present study was primarily concerned with the interaction of the independent variables of age and sex in comparing the two methods of teaching Algebra I to remedial mathematics students at the community-college level.

Another study performed by Robert O. Brown and reviewed by Schramm, which compared conventional instruction with programmed instruction, yielded results which were similar to the study performed by Moses.¹⁹ Again, this experiment was performed at the secondary-school level. The outcomes of the study revealed that the experimental group using programmed material was significantly superior in general ability to the control group which was taught by conventional techniques.²⁰ This fact of superiority attained by the experimental group was maintained throughout the periodic administration of several achievement tests during the experiment. The general conclusion of the author according to Schramm was that no student was penalized in his level of mathematics achievement

¹⁹Schramm, op. cit., p. 26.

²⁰Ibid.

because of the use of programmed materials.²¹ However, this conclusion does not actually indicate a preference of one technique of presentation over the other. In essence the concluding statement simply implies that the implementation of programmed materials in a classroom environment will not harm the students. Then the significance of these results seem rather limited as was the case with the results in Moses' study.

Perhaps a study performed by F. S. Blair²² seemed to yield significant conclusions, but the applicability of the conclusions to the stated purpose of his study would tend to make one believe that the title of his study was incorrect. After performing a "comparative analysis" of programmed instruction versus conventional instruction in Algebra I at the high-school level, Blair's first conclusion was based upon the lower limits of academic achievement for entrance into Algebra I.²³ Albeit that he also makes conclusions concerning the results of his comparative analyses; however, the fact persists that his apparently major conclusion does not seem to be related to the purpose of his study.

²¹Ibid.

²²Frank S. Blair, "A Comparison of Programmed Instruction and the Conventional Lecture-Discussion Method of Instruction in Teaching Algebra I in the Ogden City Schools," Dissertation Abstracts, XXIV (1964), 4465.

²³Ibid.

Yet, the significance of his secondary conclusions which have pertinence in light of the present study seem more substantial and meaningful in the sense that they apply more to other similar academic institutions than would the conclusions say, of Moses. One of these conclusions was that "programmed learning did not increase teacher capabilities or give the teacher time for individual help and encouragement needed."²⁴ Blair also believed that the student pressures for academic achievement were not reduced through the application of programmed instruction. It was concluded that programmed techniques should be utilized mainly with highly motivated students who could be encouraged to work at their own rate and also achieve the goals of the course.²⁵ Although the present study was related to Blair's study in the sense that they are comparisons between two techniques of teaching Algebra I, the differences in emphasis upon variables considered in both studies and the difference in age groups will prevent a replication of studies. However, the factor of motivation in Blair's study as being indicative of an optimal mode of presenting programmed algebra to students might also be considered an underlying factor that might possibly cause the rejection of the first and second hypotheses of the present study which state that there will be no significant difference in level of achievement between older students and younger

²⁴Ibid.

²⁵Ibid.

students using conventional instruction or programmed instruction; that is, the older students' motivation might be a major reason for their success in using programmed materials.

Another study in Schramm's review, by John F. Feldhusen,²⁶ was considered since it substantiated the contentions that many studies reveal little or no significant difference in conventional presentations versus programmed instruction. This study was performed with two matched groups of seventh-grade students in arithmetic, one group using programmed materials and the other group being taught by lecture technique for the first half of the experiment. For the second half of the experiment the groups and methods of presentation were interchanged. According to Schramm's review of Feldhusen's study, no significant differences were found between groups on achievement tests which were ~~administered at the~~ end of the first half of the experiment and at the end of the experiment.²⁷ Yet, it was found that according to the attitudes of the group, the students favored the programmed instruction over the conventional instruction. This of course could easily be indicative of the Hawthorne effect occurring among the students since it would seem reasonable that the students would be aware of the experimental study in light of changing from one technique of presentation to the other.

²⁶Schramm, op. cit., p. 43.

²⁷Ibid.

A study performed by R. L. Kellems also reveals no significant difference between programmed techniques and conventional techniques.²⁸ The importance of Kellems' study as being relevant to the present study lies in the fact that it was performed at the college level in Algebra. Since the present study at Northern Virginia Community College is also at the college level, some of the procedures Kellems used in performing his experiment were considered in this study. However, the existence of no significant difference in Kellems' study would possibly indicate a need for a more detailed statistical analysis of the results obtained from any experiments similar to Kellems' study. Therefore, in the present study, the t-test was employed to test the equality of means of paired samples since the use of pairing seemed to be a more accurate method to ascertain the existence of any significant difference between the teaching methods. However, even though the statistical methods used by Kellems were not adopted in the present study, the result of no significant difference obtained by Kellems was considered to be a pertinent concern in this study since Kellems' study also was performed at the college level.

The independent variable of age, which was considered an important factor in the present study, also may have been a significant factor in a study performed by John L. Hughes

²⁸Robert L. Kellems, "A Comparative Analysis of the Effect of the Use of a Programmed Text on Achievement and Efficiency in College Algebra," Dissertation Abstracts, XXV (1965), 4577.

and W. J. McNamara in which they compared the use of programmed instruction and conventional instruction in an industrial environment.²⁹ The purpose of this instruction was for the students to understand the use of the IBM 7070 computer. It was found in the light of Schramm's review of this study that two classes of students using the programmed materials in the experimental group completed the work in a mean time of 8.8 hours as opposed to a mean time of 15 hours required by the two classes of students in the control group who were under a conventional form of presentation.³⁰ It was also found that the experimental group scored slightly higher than the control group on the achievement tests which were administered. In Schramm's review of Hughes and McNamara's study it was concluded that the difference in achievement was significant even after they partially eliminated the effect of difficulty in reasoning ability; and they also discovered that the students using programmed instruction favored this technique.³¹

The results of Hughes and McNamara's study could bear directly upon the expected results of the present study since one would assume that the students who took part in their experiment involving the understanding of the IBM 7070 computer were older and more mature than the average college student. The interaction of the factor of age as hypothesized in the present study could affect results similar to the conclusions

²⁹Schramm, op. cit., p. 66.

³⁰Ibid.

³¹Ibid.

in the study by Hughes and McNamara, since the range of ages of the students at Northern Virginia Community College would seem to be greater than the age range of a regular four-year college. Therefore, although this computer course may not have been similar to the remedial Algebra I course in the present study, the factor of age possibly influenced the results of the present experiment in approximately the same way that it influenced the experiment by Hughes and McNamara.

In another experiment by D. F. Devine, comparing programmed instruction versus conventional instruction in Algebra I at the high-school level, the results seemed somewhat significant yet quite unrelated to the purpose of the study.³² The primary objective of Devine's study was to analyse student attitudes and achievement when using the conventional method versus the programmed method in presenting a course in Algebra I. However, Devine's results seemed to indicate no relationship to the original objective. Devine found that with experienced teachers using the method of programmed instruction the students scored significantly lower than they would have scored with the same teacher under conventional circumstances. In general, Devine concluded that if an average or above-average teacher is available, then the conventional technique of teaching should be employed, since greater achievement is attained by the students.³³ Although

³² Devine, loc. cit.

³³ Ibid.

these results seem meaningful and significant, the emphasis of the study seemed to shift from the students to the teachers. The importance of considering the results of Devine's study is not to be disregarded, but the fact that the original purpose of his study was not achieved tends to re-emphasize the actual lack of studies which achieve the purposes for which they were undertaken.

The relevance of Devine's study in the light of the present study lies in the fact that Devine's conclusions should be considered in detail before preparing a "comparative analysis" of any two methods of presenting any course. The importance of having teachers with similar professional teaching experience in a specific subject area was a significant factor to be investigated in order that the results of the comparison between conventional techniques and programmed techniques might not be strongly biased by this extraneous variable of teaching experience. Thus, the results of Devine's study prompted a thorough consideration of the teaching experience of all teachers involved in the present study. In order to eliminate further the effects of the extraneous variable of teaching experience, a maximum number of available teachers who presented the course in Algebra I at Northern Virginia Community College during the summer and fall quarters of 1970 was requested to participate in the experiment.

Summary

In summary, there seems to be a lack of studies that make significant contributions in the area of comparative analyses of programmed instruction versus conventional instruction in Algebra I at the college level. The review of the related literature did reveal several factors that deserve sufficient consideration before attempting a study similar to the ones reviewed. The adoption of the Cooperative Mathematics Test was confirmed as a valid and reliable measuring instrument to evaluate achievement after reviewing the study by Moses who used this test. The importance of having teachers involved in the experiment who have similar professional teaching experience was emphasized by Devine. Devine also emphasized the need for the involvement of a maximum number of teachers when performing an experiment similar to that in the present study. The use of a statistical test which would evaluate the variance of samples in the present experiment was encouraged by Kellems, Coulson, and Silberman in their studies. The factor of type of test question also was examined closely in Coulson and Silberman's study, revealing significant differences which might occur in the present study. In conclusion, through a review of the related literature, it was found that the present study was not a replication of any existent study since the variables that were involved and the very limited number of studies comparing or contrasting programmed Algebra I with a

conventional presentation of Algebra I at the college level tended to make the present study unique.

CHAPTER IV

FINDINGS OF STUDY

Introduction

The problem of this study was to evaluate the effectiveness upon achievement gain when using the two methods of programmed instruction and conventional instruction in presenting remedial Algebra I to the students at Northern Virginia Community College. Since the factors of previous ability, age, and sex were considered significant variants that could bias an analysis of the two methods of presentation, it was concluded that the statistical technique to be employed would be a paired comparison. Using the technique of analysis of equality of means of paired samples it was assumed that, to the greatest extent, the effects of the independent variables of previous ability, age, and sex could be eliminated from the actual comparison of the two types of presentation.

The three factors involved in forming the pairs so that the effectiveness of the programmed method and the conventional method could be evaluated were previous ability, age, and sex. To measure the ability of each student involved in the experiment, Form B of the Cooperative Mathematics Test was administered to each student. Because of the reliability of this test, the scores achieved by the students on this

pre-test were considered acceptable indicators of the ability of each student in Algebra I. However, to provide even more accuracy in evaluating previous ability at the onset of this experiment each student's mathematical background was carefully scrutinized to eliminate all students who had taken any college mathematics courses. Thus, before any comparison was performed, the students were grouped by matched pairs, according to the tested mathematical ability of each student prior to the start of the experiment, with the assumption that students who had the same pre-test score at the beginning of the experiment, had approximately the same initial ability in Algebra I.

The independent variable of previous ability (the pre-test score) was the first consideration in forming the pairs for all the statistical tests. Since the factor of previous ability was considered so essential in the formation of the pairs, the students were first paired in this experiment on the basis of identical pre-test scores.

The next consideration in forming the pairs in light of the independent variables of pre-test score, age, and sex was the factor of pairing in respect to age. Having satisfied the constraint that the pre-test scores in each pair must be equal, any attempt to have the ages in each pair identical would have been futile due to the limited sample size of sixty-seven students in programmed instruction and 193 students in conventional instruction; that is, had the pairs been formed not only on identical pre-test scores but also on identical

ages, the limited number of resultant pairs to be used in the test would have severely lowered the degrees of freedom to the extent that the results of any statistical test would not be reasonably acceptable. To satisfy the constraint of pairing on age and in order to have a sufficient number of pairs for statistical testing, the students under both methods of instruction were grouped in age classes. If a student in a particular age class in programmed instruction had the same pre-test score as a student in the same age class in conventional instruction, these two students were considered comparable after a consideration of the factor of sex which depended upon the specific hypothesis being tested. The age classes that were used for the experiment are the following: 17-19, 20-22, 23-25, 26-30, 31-35, ~~over~~ 35. Table II presents the number of students in each age class under conventional instruction and programmed instruction, along with the associated percentages for each class as related to the total number of students under each method of instruction.

To provide further clarification concerning the relationship of the distributions of the ages for both conventional instruction and programmed instruction a graphical representation is included as Figure 1, page 56. A brief analysis of both distributions should reveal the relative similarity of age distribution in respect to the students under programmed instruction and the students under conventional instruction.

TABLE II
AGE CLASS SUMMARY FOR STUDENTS IN PROGRAMMED
INSTRUCTION AND CONVENTIONAL INSTRUCTION

Age class	Conventional instruction		Programmed instruction	
	Number of students	Percentage of students	Number of students	Percentage of students
19-20	77	46.07	33	49.25
20-25	47	34.45	14	16.41
25-30	29	15.02	9	13.43
26-30	18	9.42	6	8.95
31-35	2	2.40	5	7.46
Over 35	2	3.62	3	4.47
Total	195	99.38	67	99.97



Figure 1

Distribution of Ages for Students in Programmed Instruction
and Conventional Instruction

The last independent variable considered in forming the pairs for this experiment was the factor of sex. Because of the strict dichotomy of this variable, the consideration of sex in satisfying the selection of the pairs for each specific test was possible due to the flexibility in associating pairs having the same pre-test score in the same age class. That is, the variety of male students and female students within the same age class with the same pre-test scores made the actual selection of pairs feasible.

Another consideration in light of the formation of the pairs was the fact that students were allowed to choose the programmed method or the conventional method of instruction in remedial Algebra I according to personal desires. This allowance for choice in the selection of the methods was an important factor to be considered when testing the fourth hypothesis which compared the achievement gains of the students under both methods while the factors of pre-test score, age, and sex were held constant.

One last consideration in this introduction before presenting the results of the experiment should be a brief explanation of the method used in codifying the data bases and the pairs for the purpose of simplicity when cross referencing the data bases and the pairs. When the data for the students under conventional instruction and programmed instruction were first organized, each student was assigned a unique identification code to be used for reference purposes. With

each code was associated the necessary data of pre-test score, post-test score, achievement gain or change, age, and sex. Appendix G contains a computer listing in student-code-sort order of the programmed instruction student-data base and the conventional instruction-student-data base. Also included in Appendix G is a separate computer listing in pair-number-sort order of the pairs of students used in each statistical test. Thus, if it is desired to cross reference any specific student in one of the listings of pairs to the same student in one of the data bases or possibly another listing of pairs, then the student code should serve as the basis for a rapid cross reference. Also, if it is desired to know the basic information concerning a specific student in a pair that is considered during the presentation of the statistical analyzer in this chapter, it is only necessary to use the code associated with that student in the data bases presented in Appendix G. Thus, the existence of the student code as a basis of cross reference should provide great facility and flexibility to anyone desiring to investigate the independent variables of the students involved in the pairs which have been selected for each statistical test. It should be reiterated that the data base listings in Appendix G are all in student-code order, thus facilitating the rapid location of any information that is desired.

The First Subproblem

The First subproblem was to determine the present (pre-test) status of the students involved in this experiment by using the Cooperative Mathematics Test to measure the pre-test achievement level of the students in Algebra I and to obtain sex and age data.

Thus, the B Form of the Cooperative Mathematics Test--Algebra I was administered to all the students in programmed instruction and conventional instruction taking remedial Algebra I during the 1970, summer and fall quarters at Northern Virginia Community College. The raw scores achieved by the students on this pre-test were then associated with the other independent variables of age, sex, and the data concerning previous mathematics courses. These data were collected when the pre-test was administered, through the distribution of a form specifically constructed for collecting such data for this experiment. A copy of this form can be found in Appendix A.

Next the raw scores attained on the pre-test by the students planning to take either programmed Algebra I or conventional Algebra I were associated with the age and sex data. These forms then were checked to eliminate all the students who were ineligible to participate in the experiment. The purpose for this elimination was to allow the groups being compared to be as similar as possible at the onset of the experiment.

The forms that remained after eliminating ineligible participants in the experiment comprised the two basic data bases to be used in the comparison of conventional instruction versus programmed instruction. To eliminate any personal association with a particular student and to provide a means for rapid cross reference, a unique student code was assigned to each student.

The Second Subproblem

The second subproblem was to obtain achievement scores on an alternate form of the Cooperative Mathematics Test at the termination of this experiment. The A Form of the test was administered to all the students who successfully completed the programmed Algebra I course and to all the students who were still in the conventional Algebra I classes at the end of the quarter. All the students remaining in the conventional Algebra I courses were administered the post-test even though they might already have been considered ineligible for the previous reasons stated in Chapter II of this study. The rationale for testing those students in conventional Algebra I, who were already eliminated from the experiment due to their ineligibility, was to avoid the possibility that the students would become aware of their participation in an experiment; that is, if the students had been aware of their participation in an experimental situation, the results obtained from testing could easily have been biased. When all the raw scores on the post-test were obtained, the score

for each student on the post-test was associated with the score that the same student obtained on the pre-test, and the achievement gain was recorded (see Appendix G).

The Third Subproblem

The third subproblem was to make a comparative analysis of the results of the scores attained by the students prior to the experiment and at the termination of the experiment on the Cooperative Mathematics Test. In order to evaluate the third subproblem in light of the independent variables of age and sex, along with the dependent variable of achievement gain, several hypotheses were initially stated and since have been tested. All the hypotheses of this study were associated with the third subproblem.

Each hypothesis was considered and the test or tests associated with the statistical evaluation of the hypothesis was presented. As stated in Chapter II, concerning the methodology, all the statistical tests of the hypotheses involved paired samples, and the t-test for testing the equality of means of paired samples was used throughout all the evaluations of the hypotheses.

The first hypothesis. The study hypothesized that there would be no significant difference in level of achievement between older and younger students, under conventional presentations. In this first hypothesis, which evaluated the significance of age in relation to achievement gain, the

upper-third-age group of students was paired with the lower-third-age group of students. On page 56 of this study, the graphical representation of the distribution of ages for students under both methods of presentation should provide some insight as to the age distribution of the population sample for conventional instruction. The upper-third-age group, from which the pairs were selected, consisted of those students who were twenty-three years old or older, but less than fifty-three years old ($23 \leq \text{age} < 53$). The lower-third-age group consisted of those students who were seventeen or eighteen years old ($17 \leq \text{age} < 19$). There were fifty-nine students in the upper-third-age group, which was 30.6 percent of the total number of students (193) involved in this study under the conventional presentation; and there were seventy-one students in the lower-third-age group which was 36.8 percent of the total number of students under the conventional instruction. It was from these two age groups that the pairs were selected to test the significance of age relative to conventional instruction. The actual pairs were formed by selecting a student from the older age group and a student from the younger age group who had identical pre-test scores. Next, the difference in achievement gains of each of the selected pairs was computed and the t-test for the equality of means of paired samples was applied to evaluate the significance of age in respect to achievement gain. Table III presents the achievement gain differences obtained for each pair involved

TABLE III

PAIRED DATA FOR TEST OF SIGNIFICANCE OF AGE ON ACHIEVEMENT
GAIN FOR CONVENTIONAL INSTRUCTION

Pair Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Achievement	13	16	18	13	9	18	17	17	16	11	15	14	13	17	18	3	21	15	17	16
Gain	19	13	10	5	10	10	15	16	8	5	2	8	6	8	13	20	6	4	3	17
Difference in gain	-6	3	8	8	-1	8	2	1	2	6	13	6	7	9	5	-17	15	11	9	3

Pair Number	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Achievement	5	6	3	11	9	-3	12	11	12	12	7	12	0	10	6	9	13	8	9	5
Gain	17	7	14	12	6	9	11	7	3	10	8	11	8	-1	7	0	8	-1	+	-6
Difference in gain	-12	-1	-11	-1	3	-12	1	+	9	2	-1	1	-8	11	-1	9	5	9	3	14

in the test. A complete listing in pair-number-sort order of the pairs involved in this test can be found in Appendix G if a more thorough investigation of the pairs is desired.

In performing the t -test, the total number of pairs from the sample population (n) was forty ($n=40$) and the degrees of freedom were thirty-nine (39). The level of significance adopted for testing the null hypothesis of no significant difference in achievement gain relative to age was at the 5 percent level ($\alpha = .05$). Having performed the computations needed to test the equality of the sample means with a mean difference $\bar{d}=3.475$, the calculated value for the t statistic obtained was 2.6922. This calculated value for the t -statistic ($t=2.6922$) caused the rejection of the null hypothesis in favor of the alternative hypothesis since the value which t must be at the 5 percent level of significance in a two-tailed test with the degrees of freedom thirty-nine (reject if $t > t_{.975}(39) = 2.021$). Therefore, the independent variable of age was a significant factor when considering achievement gain in conventional instruction for a population of students with a relatively large age span. From the latter result, it seems possible to conclude that as the age of the student increases, his ability to achieve remedial Algebra I under a conventional presentation also increases. It should be noted that the oldest student involved in this test after the pairs were formed was forty-eight years old and the youngest student in this test was seventeen years old. Thus, the first hypothesis,

that there would be no significant difference in the achievement gain for older students versus younger students using conventional techniques to learn remedial Algebra I, was rejected in favor of the alternative hypothesis, that age is a significant factor to be considered when presenting remedial Algebra I to students under the conventional presentation at the community-college level. Included in Appendix G, which has a listing of the paired samples involved in this test, are the statistical calculations which yielded the results for this test.

The second hypothesis. The study hypothesized that there would be no significant difference in level of achievement between older students and younger students using programmed instruction. As in the first hypothesis, the upper-third-age group of students was paired with the lower-third-age group of students. Again, the graphical representation providing more insight concerning the distribution of ages for the students under both methods of presentation can be located at the beginning of this chapter for those students under programmed instruction. The upper-third-age group from which the pairs were selected to test the second hypothesis consisted of those students who were twenty-three years old or older but less than fifty-three years old ($23 \leq \text{age} < 53$). The lower-third-age group consisted of those students who were seventeen or eighteen years old ($17 \leq \text{age} < 19$). There were twenty-three students in the upper-third-age group, which was 34.3

percent of the total number of students (67) involved in this study under the programmed presentation; and there were twenty-eight students in the lower-third-age group, which was 41.8 percent of the total number of students using the programmed instruction. It was from these two age groups that the pairs were selected to test the significance of age relative to programmed instruction. The actual pairs were formed as in testing the first hypothesis, by selecting a student from the older group and a student from the younger group who had identical pre-test scores. Next, the difference in achievement gains of each of the selected pairs was computed and the t-test for the equality of means of paired samples was applied to evaluate the significance of age in respect to achievement gain. Table IV presents the achievement gain differences obtained for each pair involved in the test. A complete listing in pair-number-sort order of the pairs involved in this test can be found in Appendix G if a more thorough investigation of the pairs is desired.

In performing the t-test, the total number of pairs from the sample population was twelve ($n=12$) and the degrees of freedom were eleven ($df=11$). The level of significance adopted for testing the null hypothesis of no significant difference in achievement gain relative to age was at the 5 percent level ($\alpha=.05$). Having performed the computations needed to test the equality of the sample means with a mean difference, $\bar{d}=2.4166$, the calculated value for the t-statistic

TABLE IV
 PAIRED DATA FOR TEST OF SIGNIFICANCE OF AGE ON
 ACHIEVEMENT GAIN FOR PROGRAMMED
 INSTRUCTION

Pair number		1	2	3	4	5	6	7	8	9	10	11	12
Achievement gain	Older subject	7	20	19	16	9	7	5	16	9	14	12	8
	Younger subject	7	10	14	12	1	7	4	10	7	2	12	12
Difference in gain		0	10	5	4	8	0	1	6	2	9	0	-4

obtained was 2.755. This calculated value of the t-statistic ($t=2.755$) caused the rejection (reject if $t > t_{.975}(11)=2.201$) of the null hypothesis in favor of the alternative hypothesis since the value of t at the 5 percent level of significance in a two-tailed test with the degrees of freedom eleven was exceeded ($t=2.755 > 2.201$). Therefore, the independent variable of age was a significant factor when considering achievement gain in programmed instruction for a population of students with a relatively large age span. From the results of the test of the second hypothesis it seems possible to conclude that as the age of the student increases, his ability to achieve remedial Algebra I under a programmed presentation also increases. It should be pointed out that the oldest student involved in this test after the pairs were formed was forty years old and the youngest student in this test was seventeen years old. The fact that the percentage of students considered to be in the older-age-group (41.8 percent) was somewhat greater than one-third as specified in the definition of the older-age-group was due to the need for a sufficient number of students in forming the pairs. However, the critical limit of ten being the least possible pairs that could be considered meaningful and statistically acceptable in this type of a test was satisfied.

Thus, the second hypothesis, that there would be no significant difference in the achievement gain for older students versus younger students using programmed instruction to

Learn remedial Algebra I, was rejected in favor of the alternative hypothesis that age is a significant factor to be considered when presenting remedial Algebra I to students using programmed techniques at the community-college level. Included in Appendix G, which has a listing of the paired samples involved in this test, are the statistical calculations which yielded the results for this test.

The third hypothesis. The study hypothesized that there would be no significant difference in achievement between male and female students of the same age. To test this hypothesis, paired comparisons of male students and female students in the same age classes were undertaken for students taught by conventional instruction and for students taught by programmed instruction. Next, to analyze the effect of sex upon programmed instruction versus conventional instruction, the female students in programmed instruction were paired with the male students in conventional instruction, and the male students in programmed instruction were paired with the female students in conventional instruction to ascertain the effect of sex upon the achievement gain under both methods of instruction. Therefore, by these tests of equality of means of paired samples for these four groups of pairs it was assumed that the interaction of the independent variable of sex would be thoroughly evaluated as this variable might have any possible effect upon the achievement of the students.

The first test performed in evaluating the third hypothesis involved the comparison of male students and female students who were taught only by the programmed method. In forming the pairs to test this hypothesis, students of opposite sex were considered comparable if they had identical pre-test scores and were also in the same age class. Because of the limited sample size of students in programmed instruction that could be considered in this experiment, the number of pairs for this test was minimal. Table V presents the achievement gains of the pairs involved in this test and the difference in achievement for each pair.

A list of the pairs in pair-number-sort order used in this test can be found in Appendix G. The sample size ($n=11$) used in this test was assumed to be sufficiently large enough, especially when considering the special emphasis afforded the exactness used in forming the pairs. The rationale for proceeding with this limited sample size is also substantiated by the reference to Dixon and Massey in Chapter II, when the factor of sample size when using paired samples was investigated.¹

The t-test of equality of means for paired samples was used in the statistical analysis of the pairs involved in this test for the significance of achievement gain for male students

¹Wilfred J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (New York: McGraw-Hill Book Company, 1957), p. 125.

TABLE V
 PAIRED DATA FOR MALE STUDENTS VERSUS FEMALE
 STUDENTS IN PROGRAMMED INSTRUCTION

Pair number		1	2	3	4	5	6	7	8	9	10	11
Achievement gain	Female subject	11	14	12	7	4	11	5	12	8	6	5
	Male subject	18	17	14	1	7	10	15	9	12	14	2
Difference in gain		-7	-3	-2	6	-3	1	-10	3	-4	-8	3

versus female students under programmed instruction. The calculated value of t obtained for this test was $t = -1.43$. In referencing the t -table for a two-tailed test with the degrees of freedom being ten ($df=10$), the value beyond which the null hypothesis would be rejected at the 5 percent level of significance ($\alpha=.05$) was -2.228 (reject if $t > t_{.975}(10) = -2.228$). Since the calculated value of t obtained for this test did not exceed the value of t from the t -table ($t = -1.43 > -2.228$), the null hypothesis that the independent variable of sex in this experiment would have no significant effect upon achievement gain in programmed instruction was accepted. The calculations used in computing the t -value for the pairs in this test can be found in Appendix G along with the data-base summary for the pairs used in this test.

The result of no significant difference in this test would seem to be inconsistent with the differences in gain as indicated in Table V. However, the limited sample size in this specific test, and the trend of no significant difference in the following three tests based upon the independent variable of sex make the result of no significant difference for sex in this test more acceptable. In order to obtain a significant difference in this test, the present level of significance ($\alpha=.05$) would have to be increased from $\alpha=.05$ to $\alpha=.1$ in a one-tailed test or $\alpha=.2$ in a two-tailed test. This increase of the level of significance would only tend to make the results of the present study less reliable, and the overall

interpretation of the study would be confused by any variance in the selected level of significance ($\alpha=.05$).

The second test performed in evaluating this hypothesis, which considered the effects of sex upon the achievement gain of the students under programmed instruction and conventional instruction, involved the comparison of male students and female students who were taught only by the conventional method of instruction. The method of forming the pairs for this test was identical to the method used in forming the pairs for the previous test. The emphasis in forming the pairs for this test also was on identical pre-test scores for each pair. Because of the larger number of students under conventional instruction, the number of resultant pairs for this test was quite adequate ($n=42$). Table VI presents the achievement gains for each student and the achievement difference within each pair used in performing this test. A list of the pairs in pair-number-sort order used in this test can be found in Appendix G.

The t-test of equality of means for paired samples was used in the statistical analysis of the pairs involved in this test of significance of achievement gain for male students versus female students under conventional instruction. The calculated value t which was obtained for this specific test was t=.358. In referencing the t-table for a two-tailed test with the degrees of freedom being forty-one ($df=41$), the value beyond which the null hypothesis would be rejected at the

TABLE VI

PAIRED DATA FOR MALE STUDENTS VERSUS FEMALE STUDENTS
IN CONVENTIONAL INSTRUCTION.

Pair number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Achievement	12	13	10	10	14	8	16	8	8	17	17	5	6	11	15	8	7	20	12	8
Gain	13	16	6	16	13	10	15	6	8	3	13	8	8	5	11	13	9	9	3	8
Difference in gain	-6	-3	4	-6	1	-2	1	2	0	8	-	-3	-2	6	4	-5	-2	11	7	-3

Pair number	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Achievement	8	17	5	11	17	7	-2	2	6	7	7	11	8	9	2	10	11	7	0	1	2
Gain	10	16	12	4	16	14	12	8	9	3	5	12	4	-4	2	8	13	-1	8	-6	-
Difference in gain	-2	1	-7	7	1	-7	44	-6	-3	4	-1	-1	4	13	0	2	-2	8	-8	7	3

5 percent level of significance ($\alpha=.05$) was 2.021 (reject if $t > t_{.975}(41)=2.021$). Since the calculated value of t obtained for this test did not exceed the value of t from the t -table ($t=.558 < 2.021$), the null hypothesis that the independent variable of sex in this experiment would have no significant effect upon achievement gain in conventional instruction was accepted. The calculations used in computing the t -value for the pairs in this test can be found in Appendix G along with the data-base summary of the pairs used in performing this test.

The third test used in evaluating the effect of sex upon achievement gain in this experiment involved a comparison between female students in programmed instruction and male students in conventional instruction. The method used in forming the pairs for this test was similar to the method used for the previous test which specifically emphasized the need for identical pre-test scores within each pair; however, regarding the independent variable of sex, the male member of the pair was from the conventional data base of students, while the female member was from the programmed data base of students. Minimal concern was afforded the paired sample size ($n=17$) for this test, since it was sufficiently larger than the minimum number of pairs ($n=10$) required for reasonably acceptable results as stated in Chapter I. Table VII presents the achievement gains of the pairs involved in this test and the difference in achievement for each pair. A list of the pairs

TABLE VII
 PAIRED DATA FOR MALE STUDENTS IN CONVENTIONAL INSTRUCTION VERSUS
 FEMALE STUDENTS IN PROGRAMMED INSTRUCTION

Pair number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Achievement gain	Female subject																
	13	17	10	14	12	11	4	11	7	5	12	4	8	3	6	3	2
Male subject																	
	14	13	15	9	2	9	6	10	14	12	3	12	13	2	-1	7	-2
Difference in gain																	
	-1	4	-5	5	10	5	-2	1	-1	-1	9	-8	-5	1	1	-2	4

in pair-number-sort order used in this test can be found in Appendix G.

The t-test of equality of means for paired samples was used in the statistical analysis of the pairs involved in this test of the significance of achievement gain for female students in programmed instruction versus male students in conventional instruction. The value of t which was calculated in this specific test was $t = .0156$. In referencing the t-table for a two-tailed test with the degrees of freedom being sixteen ($df=16$), the value beyond which the null hypothesis would be rejected at the 5 percent level of significance ($\alpha = .05$) was 2.120 (reject if $t > t_{.975}(16) = 2.120$). Since the value of t obtained for this test did not exceed the value of t from the t-table ($t = .0156 < 2.120$), the null hypothesis that the independent variable of sex in this experiment would have no significant effect upon the achievement gains of female students in programmed instruction when paired with male students in conventional instruction was accepted. The calculations used in computing the t-value for the pairs in this test can be found in Appendix G along with the data-base summary of the pairs used in performing this test.

The fourth and final test of the third hypothesis which involved the evaluation of the independent variable of sex upon achievement gain compared female students in conventional instruction and male students in programmed instruction. The method used in forming the pairs for this test emphasized the

desire for having identical pre-test scores within each pair; however, each pair that was formed had to have the male member of the pair from the programmed data base of students and the female member of the pair from the conventional data base of students. Since the paired sample size for this test was sufficiently large ($n=21$), minimal concern was given to the need for a paired sample size large enough to give reasonably reliable results. Table VIII presents the achievement gains of the pairs involved in this test and the difference in achievement for each pair. A list of the pairs in pair-number-sort order used in this test can be found in Appendix G.

The t-test of equality of means for paired samples was used in the statistical analysis of the pairs involved in this test of the significance of achievement gain for female students in conventional instruction versus male students in programmed instruction. The value of t which was computed in this specific test was $\underline{t}=1.26$. In referencing the t-table for a two-tailed test with the degrees of freedom being twenty ($df=20$), the value beyond which the null hypothesis would be rejected at the 5 percent level of significance ($\alpha=.05$) was 2.086 (reject if $\underline{t} > \underline{t}_{.975}(20)=2.086$). Since the value of t obtained for this test did not exceed the value of t from the t-table ($\underline{t}=1.26 < 2.086$), the null hypothesis that the independent variable of sex in this experiment would have no significant effect upon the achievement gains of female students in conventional instruction when paired with male students in programmed instruction was accepted. The calculations used in

TABLE VIII
 PAIRED DATA FOR MALE STUDENTS IN PROGRAMMED INSTRUCTION VERSUS
 FEMALE STUDENTS IN CONVENTIONAL INSTRUCTION

Pair number																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Achievement Gain	17	5	11	15	16	20	17	4	9	8	5	-2	11	7	11	5	9	10	7	0	1
	17	14	9	16	13	1	9	7	10	10	11	15	9	10	12	6	10	12	14	13	
Difference in Gain *	0	-9	2	-1	-3	19	8	-3	-1	-2	-6	-17	2	-3	-1	2	-1	-2	-7	-13	-6

computing the value for t for the pairs involved in this test can be referenced in Appendix G along with the data-base summary of the pairs used in performing this test.

Having performed the last four tests involving various paired samples, it was concluded that the independent variable of sex had no significant effect upon the achievement gain of students taking remedial Algebra I in either programmed instruction or conventional instruction at Northern Virginia Community College. That is, no significant difference in achievement in remedial Algebra I could be ascertained for male students versus female students when these students were paired separately under programmed instruction and conventional instruction, or when they were paired with one member of a pair being under one method of instruction and the other member of the same pair being under the other method of instruction. Based upon these results, it seemed reasonable to conclude that the interaction of the independent variable of sex upon programmed instruction and conventional instruction caused no significant difference in the achievement of remedial Algebra I between male and female students when using one method of presentation rather than the other method of presentation. Since no significant difference was obtained in all of the four tests involving the effect of sex upon achievement gain, the third hypothesis was accepted.

The fourth hypothesis. The study hypothesized that there would be no significant difference in achievement between the students in programmed instruction and students in conventional instruction, when the students were paired according to the independent variables of age and sex to eliminate the effects of these variables. This last hypothesis to be tested culminates the statistical analyses of this study involving the comparison of achievement gains in programmed instruction versus conventional instruction in remedial Algebra I at Northern Virginia Community College.

In forming the pairs for this last paired comparison, the consistency of this study was maintained in the sense that primary concern was given to the factor of identical pre-test scores for each pair that was formed. Therefore, each pair in this test had identical pre-test scores and the ages for the students in each pair were as near as possible to being identical while never exceeding the age class boundaries of this study. One member of each pair was taught by programmed instruction and the other member was taught by conventional instruction, while both members of a given pair were of the same sex. Having selected the pairs for this test, the difference in achievement gains for both members of each pair was computed and the differences in achievement gains for all the pairs in this test was the basis for the actual statistical comparison. Using the differences in achievement gains for all the pairs, the t-test for the equality of means of paired

samples was applied to evaluate the possible existence of a significant difference between achievement gains in programmed instruction and conventional instruction while the variables of pre-test scores, age, and sex were held constant. Table X presents the achievement gain differences obtained for each pair involved in the test. A complete listing in pair-number-sort order of the pairs involved in this test can be found in Appendix G if a more thorough investigation of the pairs is desired.

In performing the t-test of equality of means for paired samples, the total number of pairs involved was forty-one and the degrees of freedom were forty. The need for a sufficient number of pairs in order for the results to be reliable was satisfied. The level of significance adopted for testing the null hypothesis of no significant difference in achievement gain for students relative to programmed instruction and conventional instruction, while holding the independent variables of age, sex, and pre-test scores constant, was at the 5 percent level ($\alpha=.05$). Having performed the computations needed to test the equality of the sample means with a mean difference $\bar{d}=.0975$, the calculated value of the t-statistic obtained was -0.09735 . This calculated value for the t-statistic ($t=-0.09735$) caused the acceptance of the null hypothesis that no significant difference in achievement gain would exist between programmed instruction and conventional instruction with the independent variables held constant. The

TABLE IX

PAIRED DATA FOR TEST OF SIGNIFICANCE OF ACHIEVEMENT GAIN FOR PROGRAMMED INSTRUCTION VERSUS CONVENTIONAL INSTRUCTION WHILE HOLDING THE VARIABLES OF PRE-TEST SCORE, AGE, AND SEX CONSTANT

Pair number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Achievement gain	18	15	10	14	17	14	12	9	16	-2	1	7	7	9	4	7	10	10	11	11	7	5
Difference in gain	13	15	16	17	15	8	6	5	11	18	9	20	21	17	4	6	9	10	3	11	7	-2
	5	0	-6	-3	2	6	6	4	5	-20	-8	-13	-14	-8	0	1	1	0	3	0	0	7

Pair number	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
Achievement gain	15	11	14	12	9	10	11	12	6	2	12	4	3	6	14	13	2	2	-3
Difference in gain	14	10	11	11	3	8	10	12	4	-4	8	10	11	7	-1	8	7	-2	0
	1	1	3	1	6	2	1	0	2	6	4	-6	-8	-1	15	5	-5	4	-3

null hypothesis was accepted since the value of t from the t -table at the 5 percent level of significance in a two-tailed test with the degrees of freedom forty (reject if $t < t_{.975}(40) = -2.021$) was not exceeded ($t = -0.09735 > -2.021$). With the independent variables of pre-test scores, age, and sex eliminated from effecting the statistical comparison of both teaching methods, it was concluded that students of the same age and sex with equal ability could achieve remedial Algebra I equally well under either method of instruction. Thus, the fourth hypothesis, that there would be no significant difference in achievement between the students in programmed instruction and the students in conventional instruction when the students were paired according to the independent variables of pre-test scores, age, and sex, was accepted. Included in Appendix G, which has a listing of the paired samples involved in this test, are the calculations which yielded the results for this test.

The Fourth Subproblem

The fourth subproblem was to make an interpretation of the results of the analysis in the third subproblem in order to determine the weights of the factors of age and sex upon the outcome of this experiment. In satisfying the requirements of the fourth subproblem, a brief interpretation of the overall statistical results of all the tests of the hypotheses will be presented followed by several summarizing statements.

To assist in the interpretation of the statistical results, two graphs (Figures 2 and 3) are provided on the following pages to illustrate the distribution of scores and the differential in achievement gain for students using programmed instruction and for students taught by conventional techniques. One graph indicates the pre-test and post-test score distributions for the students in programmed instruction, and the second graph indicates the pre-test and post-test score distributions for the students in conventional instruction.

Since a significant difference in achievement was obtained in the analysis of the independent variable of age under both programmed instruction and conventional instruction, it seems reasonable to conclude that the method of paired comparisons selected for this study was the best method. That is, had the independent variable of age, which was held constant during the comparison of achievement gains under both methods, been allowed to interact in the actual comparison of the two methods of instruction, it would have possibly revealed a significant difference in achievement gain between programmed instruction and conventional instruction. The significance of age, as this factor relates to achievement gain, was further substantiated and supported by a statistical study performed at Northern Virginia Community College in which student grades were analyzed as they related to the age of the students at the College. This analysis was performed by J. Michael Mullen,

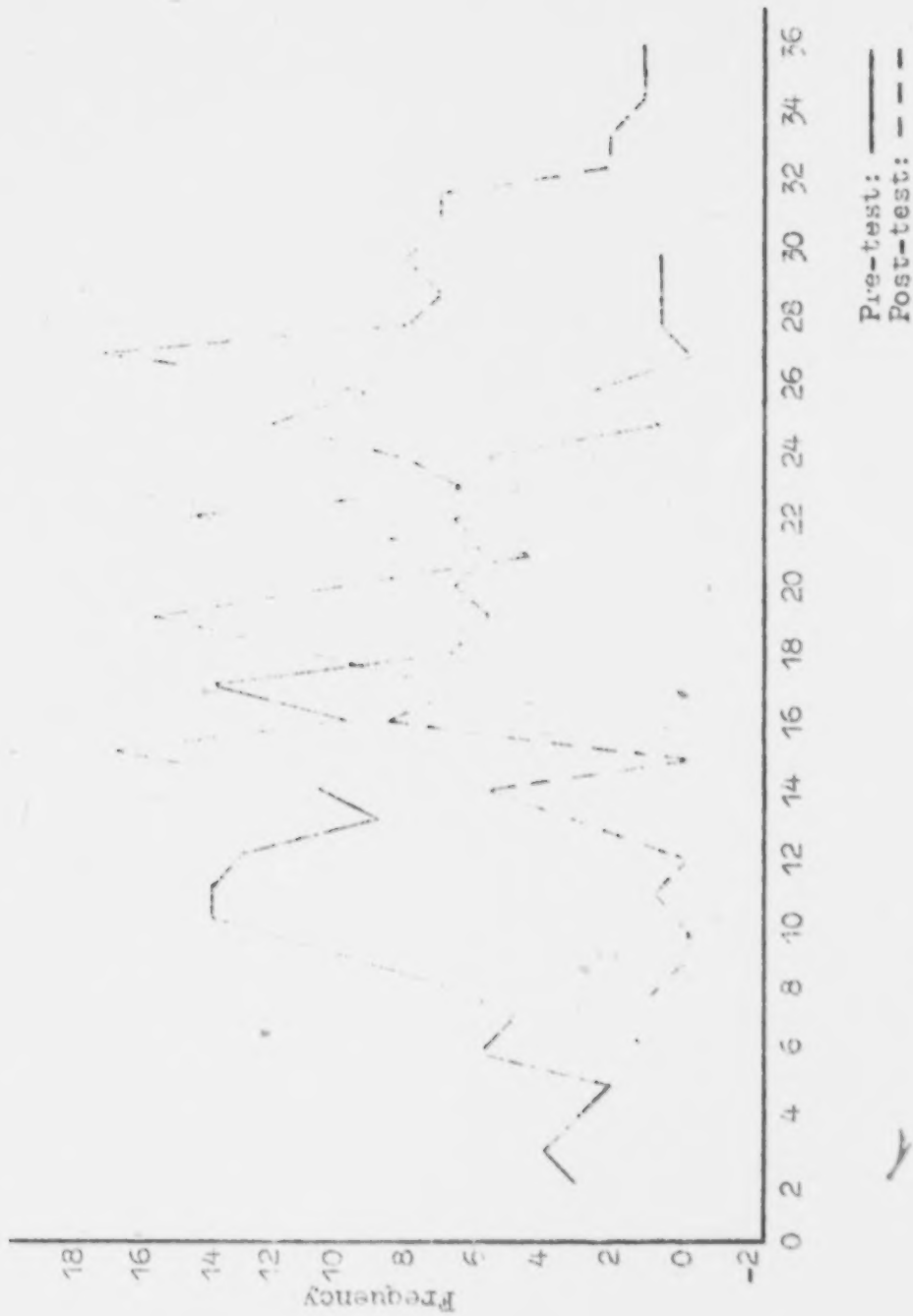


Figure 3

Distribution of Pre-Test - Post-Test Scores, Conventional Method

Coordinator of Institutional Research at Northern Virginia Community College. The results of this analysis, which are presented in Tables X and XI, reveal the fact that the ages of the students increased, so also the grade-point averages of the students increased. Thus, the significance of the independent variable of age as related to the present study seems to parallel the trend of age as related to achievement for all the students at Northern Virginia Community College.

However, when students of the same age in remedial Algebra I were paired on opposite sex, there was no significant difference in achievement gain, no matter whether the students were paired under only one method of instruction or whether the students of each pair were selected with one student from each method of instruction. The fact that no significant difference in achievement gain for male students versus female students was revealed by this study was interesting since male students are frequently assumed to be more capable of achieving the concepts of remedial Algebra I; however, the significance of sex in relation to its effect upon achievement gain in Algebra I may be less, after the secondary years of education. Hence, in the light of the two independent variables of age and sex, it seems reasonable to conclude that as the age of a student increases, his achievement of mathematics, in this case remedial Algebra I at the community-college level, increases for these age classes, and the significance of sex upon achievement becomes less relevant.

TABLE X
STUDENT AGE/GRADE ANALYSIS*
FALL QUARTER, 1970

Age	Evening classes			
	Central campus		Eastern campus	
	Number	Average**	Number	Average**
21-Under	1,319	2.01	584	2.23
22-25	1,008	2.52	830	2.45
26-29	527	2.78	403	2.79
30-Over	760	2.88	532	2.75
Total	3,614	2.45	2,349	2.52

* This analysis was based upon class enrollment and pass/fail courses, incomplete grades, withdrawals, and audits were not included in the grade calculations.

** This average referred to the grade-point average of the students in a given age group.

Source: J. Michael Mullen, "Student Age/Grade Analysis" (Annandale, Virginia: Data Abstracted from report by the Office of Institutional Research, Northern Virginia Community College, 1971). (Mimeographed.)

TABLE XI
STUDENT AGE ANALYSIS*
FALL QUARTER, 1970

Age	Evening classes			
	Central campus		Eastern campus	
	Number	Percentage	Number	Percentage
21-Under	1,319	36.5	584	24.9
22-25	1,008	27.9	830	35.3
26-29	527	14.6	403	17.2
30-Over	760	21.0	532	22.6
Total	3,614	100.0	2,349	100.0

* This analysis was based upon class enrollment and pass/fail courses, incomplete grades, withdrawals, and audits were not included in the grade calculations.

Source: J. Michael Mullen, "Student Age/Grade Analysis" (Annandale, Virginia: Data abstracted from report by the Office of Institutional Research, Northern Virginia Community College, 1971). (Mimeographed.)

Of the many possible reasons that might be considered as causes for this phenomenon, it seems likely that two factors for this increase in achievement as age increases could be the greater maturity of older students and their increased motivation to achieve more definite goals which are more apparent and significant to them because of the many more actual experiences older students have witnessed as opposed to younger students. Although it might seem that at a certain age or age class the increase in age would not be nearly so apparent, the age constraints of this study would not reveal at what age level the effect of diminishing returns upon achievement in Algebra I would actually become apparent.

In analyzing the results of the fourth hypothesis, which was the most important hypothesis in this study, the effect of age, previous ability, and sex were eliminated from the test; that is, this statistical test was organized so that the only factor being compared was the effect upon achievement gain when using programmed instruction and conventional instruction in teaching remedial Algebra I. There was no significance in achievement gains between the two teaching methods of programmed instruction and conventional instruction, with the elimination of the independent variables of age and sex. Therefore, a student can validly select either method of presentation of remedial Algebra I, no matter what his age or sex, and still expect to achieve the requirements of the course. Thus, the importance of no significant

100

difference obtained in the statistical test of the fourth hypothesis is revealed in the fact that either method would allow the student to achieve equally well the goals of the course. Actually, the only factor that a student would have to consider in selecting either the programmed method of instruction or the conventional method of instruction in light of this experiment would be his own personal choice to take remedial Algebra I under one method over the other method. However, the factor of personal choice, which was not evaluated in this experiment, could quite possibly cause a significant difference in achievement due to the methodology of presentation, if the choices of the students were violated and the students were forced to take remedial Algebra I under the method they did not choose. In concluding the interpretation of the fourth hypothesis of this study, it can be said that according to the students' choice, either method of instruction in remedial Algebra I would allow the student to expect to achieve the goals of the course equally well.

The following statements summarize the statistical results of the third chapter of this experimental study:

1. The independent variable of age caused a significant difference in the achievement of remedial Algebra I at Northern Virginia Community College; that is, as a student's age increased his ability to achieve remedial Algebra I also increased.

2. No significant difference in the achievement of remedial Algebra I could be ascribed to the independent variable of sex in this study.

3. The programmed method of teaching remedial Algebra I at Northern Virginia Community College caused no significant difference in achievement when it was compared to the conventional method of teaching remedial Algebra I.

4. Remedial Algebra I students at Northern Virginia Community College achieved the goals of remedial Algebra I equally well whether they accomplished these goals under programmed instruction or conventional instruction, when the element of personal choice, which allows students freedom in directing their own education, was operative in the selection of programmed instruction or conventional instruction.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to make a comparative analysis and interpretation of the students' achievement gains in remedial Algebra I when using programmed instruction versus conventional instruction at Northern Virginia Community College during the summer and fall quarters of 1970. The comparison was made in order to ascertain the effects of the independent variables of previous ability (measured by a pre-test), age, and sex upon the achievement of Algebra I under both methods of instruction. In addition to the latter analyses, the most pertinent comparison of the methodologies was undertaken to analyze the effect upon achievement gain when using programmed instruction versus conventional instruction while the independent variables were held constant.

The delimitations. Only those students between the ages of sixteen and fifty-three inclusively, who registered for remedial Algebra I at Northern Virginia Community College were allowed to participate in this experiment. The experiment excluded students who had previous experiences in college mathematics. The textbook materials were limited to a programmed

text and a conventional text which were determined to be similar, through evaluations by several faculty members. With respect to the students taking programmed instruction, only those students who achieved the entire programmed Algebra I course in one quarter were allowed to participate in this study.

The setting for the problem. This study was performed in the Developmental Mathematics Programs at Northern Virginia Community College, a state affiliated multi-campus facility serving the Northern Virginia region. Since an open-door policy is the basis for admission to the College, there is a need for a developmental program to remediate deficiencies of new students in mathematics and English before they undertake any college-level courses. The Developmental Programs on the two presently existent campuses prepare students for either a University Parallel-College Transfer Program or for Occupational-Technical Programs. All the mathematics teachers who assisted in this study were members of the Developmental Mathematics Departments at either the Eastern Campus or Central Campus of the College. The overall goal of the Developmental Studies Division at the College is to present the subject matter to the students using the best mode of presentation to meet individual student needs, thus allowing the students to complete their remedial work in the shortest possible time.

The population for this study. The population for this experimental study involved only those students who registered for remedial Algebra I at the College for the summer or fall quarters, 1970. After all ineligible students were eliminated from the experiment, according to the specific constraints stated in Chapter I, there remained 193 students who completed Algebra I under the conventional technique and 67 students who completed Algebra I under the programmed method. The previous ability of all students in the experiment, as measured by the pre-test, demonstrated extreme variations in mathematical preparation; likewise, the age span of the population was very large, with a balance for the representation of both sexes maintained throughout the age span. Therefore, the population of this study included a cross-section of students with respect to age, previous ability, and sex, not to exclude the many varied backgrounds of the students.

The experimental design. The experimental design used in the statistical analyses of the hypotheses of this study involved the use of paired comparisons. The t-statistic was employed in this study to test for the significance of the difference of the means of the paired samples for each hypothesis.

The data analysis. In analyzing the data, specific emphasis was afforded the accuracy in the formation of the pairs while still satisfying the minimum sample-size requirements for acceptable results using a paired comparison. The

5 percent level of significance ($\alpha=.05$) was specified as the level at which an hypothesis would be rejected. The employment of age classes in this experiment facilitated an increase in the number of pairs that could be formed, while allowing for the inclusion of the oldest students (thirty-one years or older), thus providing for a greater age span in the statistical tests than would have been possible without age classes. Although the independent variable of age was significant in this experiment in relation to older and younger students as defined for this study, this significance of age did not pertain to the age classes. To further clarify the presentation of the statistical results of the tests of hypotheses, tables of the pairs involved in each test were included in Chapter III. Also, included in Appendix G are the listings of data bases and the pairs for each test with the corresponding statistical calculations.

Major findings. The major findings of this study that were relevant to remedial Algebra I students at Northern Virginia Community College are listed below.

The First Hypothesis

This study hypothesized that there would be no significant difference in level of achievement between older students and younger students under conventional presentations. This hypothesis was rejected at the 5 percent level, in favor of the alternative hypothesis that age did cause a significant

difference in achievement of remedial Algebra when using conventional techniques.

The Second Hypothesis

This study hypothesized that there would be no significant difference in level of achievement between older students and younger students using programmed instruction. This hypothesis was rejected at the 5 percent level, in favor of the alternative hypothesis that age was a significant factor relative to the achievement of remedial Algebra I when using programmed instruction.

The Third Hypothesis

This study hypothesized that there would be no significant difference in achievement between male and female students of the same age. This hypothesis was analyzed by considering the effects of the factor of sex within programmed instruction and conventional instruction along with an analysis of the effects of sex when comparing both methods of instruction. All the tests indicated the acceptance at the 5 percent level, of this null hypothesis that sex was not a significant factor that could affect the achievement of remedial Algebra I.

The Fourth Hypothesis

This study hypothesized that there would be no significant difference in achievement between the students in

programmed instruction and the students in conventional instruction when the students were paired according to the independent variables of pre-test score, age, and sex to eliminate the effects of these variables. When the independent variables were held constant by the method of pairing, no significant difference between programmed instruction and conventional instruction in remedial Algebra I was revealed. Therefore, the fourth hypothesis, that the two teaching methods considered in this study would not differ, was accepted at the 5 percent level.

Conclusions

The following conclusions pertain to the results of the statistical tests of the independent variable of age upon achievement in this experiment.

1. As the age of a student increases, his ability to achieve success in remedial Algebra I using either programmed instruction or conventional instruction, at Northern Virginia Community College, also increases.
2. The result of increasing age affecting an increase in achievement in this study parallels the indicated trend that is revealed in the Age-Grade Analysis presented in Chapter III. Therefore, the effect of age in this study is in agreement with the College-wide trend concerning the effect of age upon achievement.
3. The significance of age, as it effects the achievement of remedial Algebra I at the College, is pertinent not

only to programmed instruction but also conventional instruction. A possible rationale for the occurrence of this phenomena could be explained by the greater inspiration of an older and more mature student who is motivated towards definite goals.

The conclusions that follow pertain to the statistical results of the test of the third hypothesis which evaluated the significance of sex upon the achievement of remedial Algebra I by students at Northern Virginia Community College in light of the use of programmed instruction and conventional instruction.

1. The independent variable of sex did not significantly influence the achievement gain of remedial Algebra I students at Northern Virginia Community College.

2. Male students and female students at Northern Virginia Community College can select either programmed instruction or conventional instruction in remedial Algebra I without the factor of sex affecting any significant difference in achievement.

The following conclusions are associated with the statistical results of the test of the fourth hypothesis which involved a comparison of the achievement gains in remedial Algebra I when using programmed instruction versus conventional instruction, while the independent variables of pre-test score, age, and sex were held constant by using the process of pairing on these variables.

1. Any student in the remedial Algebra I program at Northern Virginia Community College can achieve the topics of this course equally well by taking the course under programmed instruction or conventional instruction according to the student's own desire.

2. The fact that there is no significant difference in achievement when using either method of presentation is very important from the standpoint of the Developmental Studies Division at Northern Virginia Community College. That is, this statistical evaluation indicates the feasibility of a continuance of the use of programmed instruction in remedial Algebra I, since the existence of two methods of presenting remedial Algebra I allows the students the opportunity to achieve the goals of the course equally well while the individual needs of the students regarding the process of learning are met.

Recommendations

Several suggestions in light of the statistical results and conclusions of this study are recommended as possible topics for further investigation and evaluation.

1. Regular evaluations of programmed instruction versus conventional instruction using the statistical model of this study should be performed at Northern Virginia Community College and the results of each evaluation should be compiled and analyzed. These regular evaluations of the methods of

presenting remedial Algebra I are necessary in order to increase the reliability of the indicated conclusions of this study.

2. The investigator recommends that an in-depth analysis of the factor of age be performed at the community-college level so that the relationship between the trend in age as indicated by the College-wide, Age-Grade Analysis discussed in Chapter IV, and the significance of age in this study may be better understood.

3. The investigator suggests that the achievement gain in remedial Algebra I that could result from a possible combination of programmed instruction and conventional instruction might be compared with the achievement gains attained under each separate method of instruction at the community-college level.

4. More studies similar to this study, which would evaluate the effects of programmed instruction versus conventional instruction, should be performed at community colleges throughout the country so that the factor of geographical location upon achievement may be analyzed. That is, certain community colleges may be in regions where one method of instruction is significantly more successful than another method of instruction.

5. The investigator recommends that a study be performed which would analyze, assimilate, and evaluate the statistical data obtained from comparisons of programmed

instruction and conventional instruction of Algebra I at the secondary level, and at all other scholastic levels beyond high school.

6. In retrospect, the factor of motivation and its effect upon the achievement of Algebra I at the community-college level was not analyzed in this study. The investigator recommends that a study be undertaken to evaluate the significance of motivation as it affects the achievement gain of remedial Algebra I students at the community-college level.

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APPENDICES

APPENDIX A

THE FORM USED TO OBTAIN THE NECESSARY DATA
FOR THE EXPERIMENT FROM THE STUDENTS AT
NORTHERN VIRGINIA COMMUNITY COLLEGE

Name: _____ Age: _____ Sex: Male: ☐
Female: ☐

Check one:
Programmed instruction: ☐
Conventional instruction: ☐ Years since high school _____

Previous high school mathematics courses: (check if you have had the course)

General high school math: ☐ Algebra I: ☐ Algebra II: ☐
Geometry: ☐ Trigonometry: ☐

Other: _____

Previous mathematics courses taken at Northern Virginia
Community College: _____

Previous mathematics courses taken at any other colleges:

Figure 4

Student Information Form

APPENDIX B

MEMORANDUMS TO THE TEACHERS AT NORTHERN VIRGINIA
COMMUNITY COLLEGE INVOLVED IN THE EXPERIMENT

NORTHERN VIRGINIA COMMUNITY COLLEGE
DIVISION OF DEVELOPMENTAL STUDIES
Central Campus

June 7, 1970

MEMORANDUM

TO: Developmental Faculty Teaching Math 001 or 003

FROM: Dave Conroy, Developmental Mathematics

SUBJECT: Experimental comparison between Alvin and Hackworth's Programmed Algebra I and the lecture course for Algebra I (Wootton and Drooyan)

1. Your assistance would be appreciated in helping me obtain data for an experimental comparison to be conducted during the summer quarter, 1970, at Northern Virginia Community College. It is requested that you administer a mathematics examination at the beginning and at the end of either your programmed Algebra I course or the math courses covering Wootton and Drooyan's first five chapters, whichever you may be teaching. I will be only concerned with Algebra I students. These cooperative tests will serve as a pre-test and post-test for the experiment. To avoid the Hawthorne effect, it is also requested that the students not know that this experiment is actually being conducted.
2. I will furnish copies of the examinations for both the pre-test and post-test along with answer keys. Along with the answer key there will be a short form to be filled out by the students in order that I may have the necessary data for the experiment.
3. For the programmed Algebra I students, the pre-test will be administered to only those students just starting Alvin and Hackworth's Algebra I; likewise, the post-test will only be administered to only those students who have completed Alvin and Hackworth's two volumes. The post-test should be administered immediately after the students complete the course. Perhaps the lab assistants could be helpful in administering the post-test.

MEMORANDUM
June 3, 1970
Page 2

4. I will be most willing to answer any questions concerning this experiment. Thank you for your cooperation.

Dave Conroy

DC:mf

Info:

Mrs. Coleman, Eastern
Mr. Wilkin, Eastern
Mr. Buckingham, Eastern
Mr. Jacobs, Eastern
Mr. Sexton, Central
Miss Horyna, Central
Mr. Clear, Central
Mr. Prince, Central

NORTHERN VIRGINIA COMMUNITY COLLEGE
DIVISION OF DEVELOPMENTAL STUDIES
Central Campus

June 12, 1970

MEMORANDUM

TO: Developmental Faculty Teaching Math 001 or 008

FROM: Dave Conroy, Developmental Mathematics

SUBJECT: Experimental comparison between Alwin and Hackworth's
Programmed Algebra I and the lecture course for
Algebra I (Wootton and Drooyan)

1. Enclosed are the tests, answer sheets, and forms to be filled in by the students involved in the experiment. To keep a close account of the tests there are numbers (in green) on each test. Please have the students put the number of their test on the answer sheet along with their name.
2. Please ask the students not to mark on the tests so that you can return them for possible redistribution to other teachers for use if needed. It would also be appreciated if the students were not aware that they are involved in an experiment, and also that they be aware that this test will not affect their grade.
3. In administering the test, the teacher should:
 - a. Pass out the forms to be filled out completely (all information will be kept confidential).
 - b. Pass out the answer sheets for the test upon which the students will write their names and the corresponding number from their test. (This is enough information for the answer sheet.)
 - c. Read instructions and tell the students to start the examination. Give them 40 minutes to work on the examination.

MEMORANDUM
June 12, 1970
Page 2

- d. Return all tests and answer sheets along with the forms to the Developmental Studies Division Office at your particular campus for pick-up.
- e. Thank you for your assistance in administering this pre-test for my experimental study. Any questions should be directed to Dave Conroy, Central Campus, extension 241.

Dave Conroy

Info:

Mr. Jacobs, Eastern
Mr. Wilkin, Eastern
Mr. Buckingham, Eastern
Mrs. Coleman, Eastern
Mr. Prince, Central
Mr. Saylor, Central
Mr. Sexton, Central
Miss Horyna, Central
Mr. Clear, Central

NORTHERN VIRGINIA COMMUNITY COLLEGE
DIVISION OF DEVELOPMENTAL STUDIES
Central Campus

August 11, 1970

MEMORANDUM

TO: Developmental Faculty Teaching Math 001 or 008

FROM: Dave Conroy, Assistant Professor

SUBJECT: Experimental comparison between Alwin and Hackworth's
Programmed Algebra I and the lecture course for
Algebra I (Wooton and Drooyan)

1. In order to obtain a measure of achievement gain for the students involved in my experiment a second form of the pre-test should be administered to the students. Those students taking Programmed Algebra I, Alwin and Hackworth, will be administered the test by the lab assistants at both campuses after taking the final examination for the programmed Algebra I. It is requested that the students taking Wooton and Drooyan's course in Algebra I be administered the post-test as near to the end of the summer quarter as possible.
2. Enclosed are the tests and answer sheets to be filled in by the students involved in the experiment. To keep a close account of the tests there are numbers (in green) on each test. Please have the students print the number of their test on the answer sheet along with their name. It is also requested that the students not mark on the tests so that they can be returned for possible redistribution to other teachers for use if needed. It would be appreciated if the students were not aware that they are involved in an experiment, and also that they be aware that this test will not affect their grade.
3. In administering the test, the teacher should:
 - a. Pass out the answer sheets for the test upon which the students will write their names and the corresponding number from their test. (This is enough information for the answer sheet.)

MEMORANDUM

August 11, 1970

Page 2

- b. Have the students check the test to ascertain that it has six sheets.
 - c. Read instructions and tell the students to start the examination. Give them 40 minutes to work on the examination.
 - d. Return all tests and answer sheets to the Developmental Studies Division Office at your respective campus for pick-up.
4. Thank you for your assistance in administering this post-test for my experimental study. Any questions should be directed to Dave Conroy, Central Campus, extension 378.

Dave Conroy

DC:af

Info:

Mr. Jacobs, Eastern
Mr. Wilkin, Eastern
Mr. Buckingham, Eastern
Mrs. Coleman, Eastern
Mr. Prince, Central
Mr. Saylor, Central
Mr. Sexton, Central
Miss Horyna, Central
Mr. Clear, Central
Mr. Flegal, Central

NORTHERN VIRGINIA COMMUNITY COLLEGE
DIVISION OF DEVELOPMENTAL STUDIES
Central Campus

September 21, 1970

MEMORANDUM

TO: Developmental Faculty Teaching Math 01 or 31

FROM: Dave Conroy, Developmental Mathematics

SUBJECT: Experimental comparison between Alwin and Hackworth's
Programmed Algebra I and the lecture course for
Algebra I (Wooton and Drooyan)

1. Enclosed are the tests, answer sheets, and forms to be filled in by the students involved in the experiment. To keep a close account of the tests there are numbers (in green) on each test. Please have the students put the number of their test on the answer sheet along with their name.
2. Please ask the students not to mark on the tests so that you can return them for possible redistribution to other teachers for use if needed. It would also be appreciated if the students were not aware that they are involved in an experiment, and also that they be aware that this test will not affect their grade.
3. In administering the test, the teacher should:
 - a. Pass out the forms to be filled out completely (all information will be kept confidential).
 - b. Pass out the answer sheets for the test upon which the students will write their names and the corresponding number from their test. (This is enough information for the answer sheet.)
 - c. Read instructions and tell the students to start the examination. Give them 40 minutes to work on the examination.

MEMORANDUM
September 21, 1970
Page 2

- d. Return all tests and answer sheets along with the forms to the Developmental Studies Division Office at your particular campus for pick-up.
4. Thank you for your assistance in administering this pre-test for my experimental study. Any questions should be directed to Dave Conroy, Central Campus, extension 373.

Dave Conroy

DC:nf

Info:

Mr. Saylor, Central
Mr. Prince, Central
Mr. Clear, Central
Mr. Bernard, Central
Mr. Mandel, Central
Miss Simpson, Central
Staff, Central
Dr. Smith, Eastern
Mr. Jacobs, Eastern
Mr. Wilkin, Eastern
Mrs. Coleman, Eastern
Mrs. Bodnar, Eastern
Mr. Buckingham, Eastern
Staff, Eastern

NORTHERN VIRGINIA COMMUNITY COLLEGE
DIVISION OF DEVELOPMENTAL STUDIES
Central Campus

November 11, 1970

MEMORANDUM

TO: Developmental Math Faculty, Central Campus

FROM: Dave Conroy

In order to eliminate unnecessary manipulation of data for my experiment, it would be appreciated if you could indicate to me those students who have transferred during the quarter from Algebra I, lecture, to Algebra I, programmed. No other information is needed other than their names. Likewise, those same students who transferred will not have to take the post-test since they will no longer qualify to be involved in my experiment.

Please write the names of the students involved at the bottom of this sheet and leave this sheet on my desk.

Thank you.

Dave Conroy

DC:nf

Info:

Mr. Saylor, Central
Mr. Prince, Central
Mr. Clear, Central
Mr. Bernard, Central
Mrs. Argue, Central
Miss Simpson, Central

NORTHERN VIRGINIA COMMUNITY COLLEGE
DIVISION OF DEVELOPMENTAL STUDIES
Central Campus

November 16, 1970

MEMORANDUM

TO: Developmental Faculty Teaching Math 01 or 31

FROM: Dave Conroy, Assistant Professor

SUBJECT: Experimental comparison between Alwin and Hackworth's
Programmed Algebra I and the lecture course for
Algebra I (Wooton and Drooyan)

1. In order to obtain a measure of achievement gain for the students involved in my experiment a second form of the pre-test should be administered to the students. Those students taking Programmed Algebra I, Alwin and Hackworth, will be administered the test by the lab assistants at both campuses after taking the final examination for the programmed Algebra I. It is requested that the students taking Wooton and Drooyan's course in Algebra I be administered the post-test as near as possible to the end of the fall quarter.
2. Enclosed are the tests and answer sheets to be filled in by the students involved in the experiment. To keep a close account of the tests there are numbers (in green) on each test. Please have the students print the number of their test on the answer sheet along with their name. It is also requested that the students not mark on the tests so that they can be returned for possible redistribution to other teachers for use if needed. It would be appreciated if the students were not aware that they are involved in an experiment, and also that they be aware that this test will not affect their grade.
3. In administering the test, the teacher should:
 - a. Pass out the answer sheets for the test upon which the students will print their names and the corresponding number from their test. (This is enough information for the answer sheet.)

MEMORANDUM

November 16, 1970

Page 2

- b. Have the students check the test to ascertain that it has six sheets.
 - c. Read instructions and tell the students to start the examination. Give them 40 minutes to work on the examination.
 - d. Return all tests and answer sheets to the Developmental Studies Division Office at your respective campus for pick-up.
4. Thank you for your assistance in administering this post-test for my experimental study. Any questions should be directed to Dave Conroy, Central Campus, extension 378.

Dave Conroy

DC:nf

Info:

Mr. Saylor, Central
Mr. Prince, Central
Mr. Clear, Central
Mr. Bernard, Central
Mr. Mandel, Central
Miss Simpson, Central
Mrs. Argue, Central
Staff, Central
Dr. Smith, Eastern
Mr. Jacobs, Eastern
Mr. Wilkin, Eastern
Mrs. Coleman, Eastern
Mrs. Bodnar, Eastern
Mr. Buckingham, Eastern

APPENDIX C

CORRESPONDENCE WITH THE EDUCATIONAL TESTING SERVICE

EDUCATIONAL TESTING SERVICE

PRINCETON, N. J. 08540

Area Code 609
921-9000
CABLE EDUC TEST SV

Russell W. Martin, Jr.
Assistant Director

July 10, 1970

Mr. David E. Conroy
13513 Carmel Lane
Chantilly, Virginia 22021

Dear Mr. Conroy:

I am writing to confirm our telephone conversation of this date. Educational Testing Service is indeed pleased to grant you permission to reproduce up to 325 copies of selected items from the Cooperative Mathematics Tests - Algebra I (Forms A and B) to be used in your doctoral research studies. Our permission is contingent upon our receiving a letter from Dr. Chalmer Gross confirming your status as a graduate student at The American University, Washington, D. C.

The permission is nonexclusive and without fee, however to protect our copyright interests we do ask that you use the following credit line on each copy of the test you reproduce:

Copyright © 1962 by Educational Testing Service.
All rights reserved. Reproduced by permission.

If the terms outlined above are satisfactory, please sign both copies of this letter in the space provided below and return one copy to me for our records.

As I explained to you, we do not permit copies of our tests to be included in theses, either in bound copies retained by university libraries or in microfilm editions, but since you do not plan to include the tests, this should present no problem for you.

We would be gratified to learn the results of your research and would appreciate your sending a copy of your findings to

Dr. Matthew Sherman
Program Director
Cooperative Tests and Services
Educational Testing Service
Princeton, New Jersey 08540

Mr. David E. Conroy

-2-

July 10, 1970

It was a pleasure to speak with you today. Please accept our good wishes for the success of your research and do not hesitate to contact us if we can be of further help.

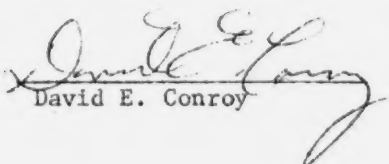
Sincerely yours,

Margaret M. Mach

Mrs. Rudolf Mach
Copyrights, Licensing, & Permissions

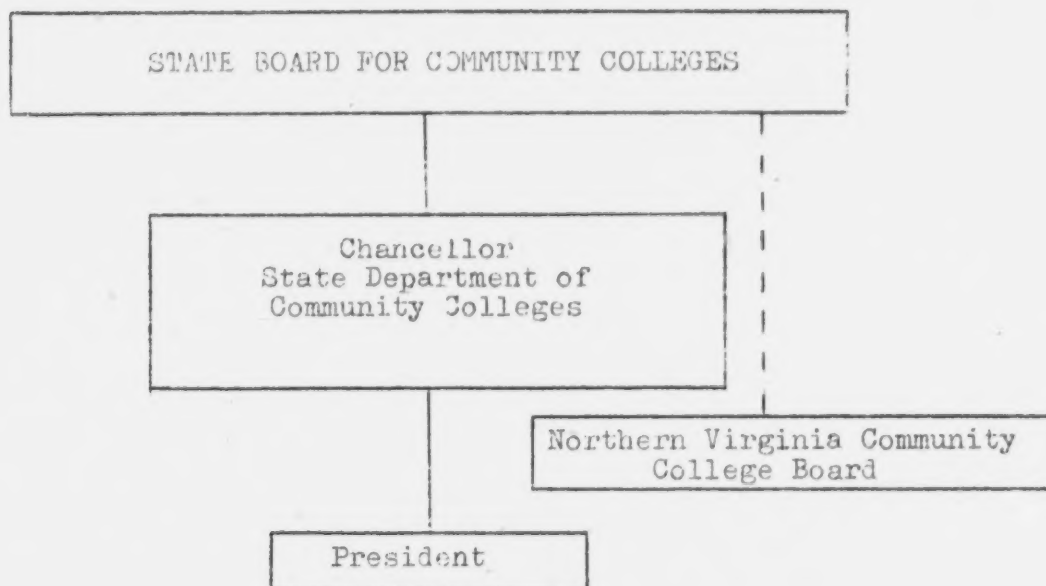
MMM/h
enclosure

ACCEPTED AND AGREED TO:


David E. Conroy

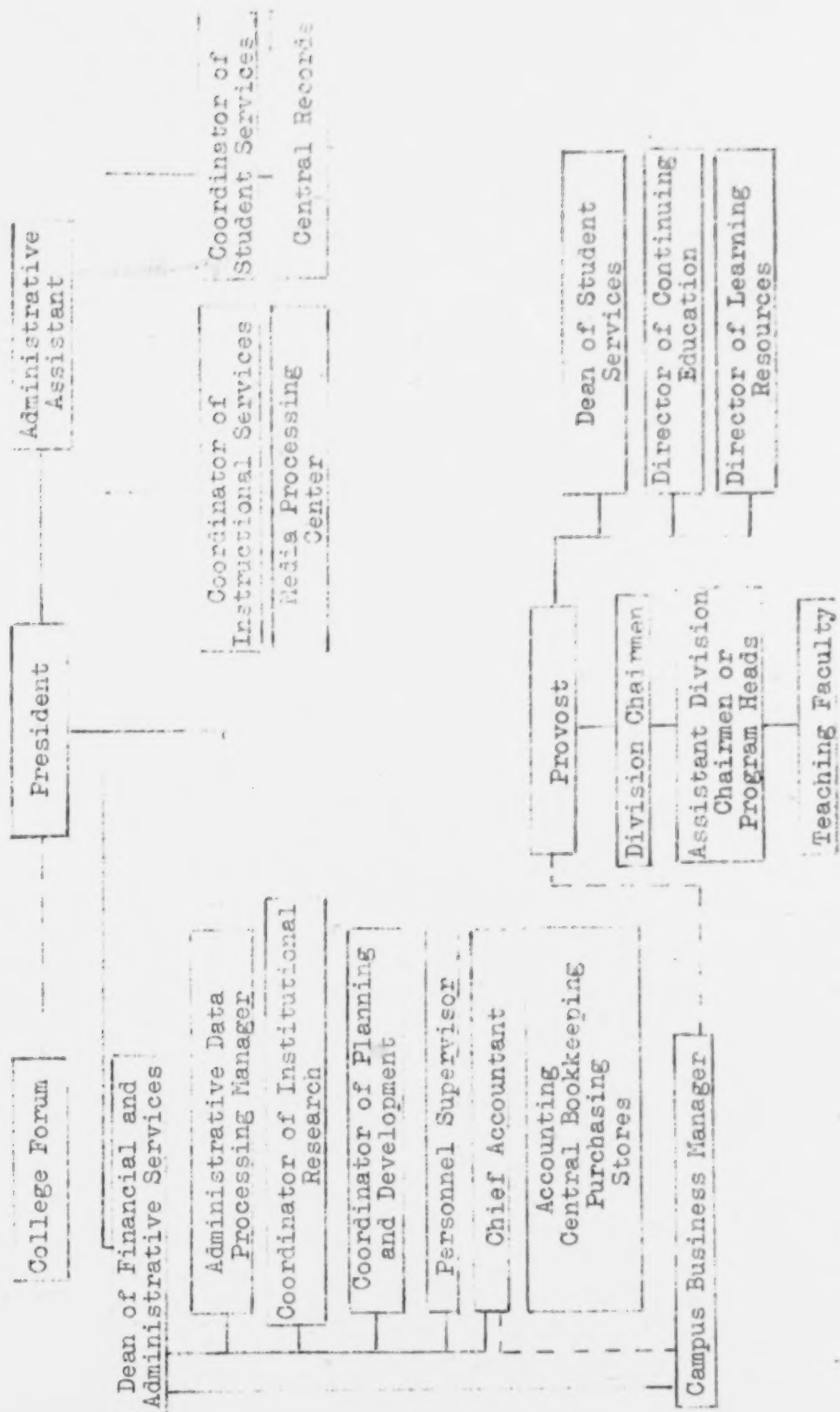
APPENDIX D

ADMINISTRATIVE ORGANIZATION CHARTS FOR
NORTHERN VIRGINIA COMMUNITY COLLEGE



Source: Faculty Handbook, Northern Virginia Community College,
1970-71, p. 8.

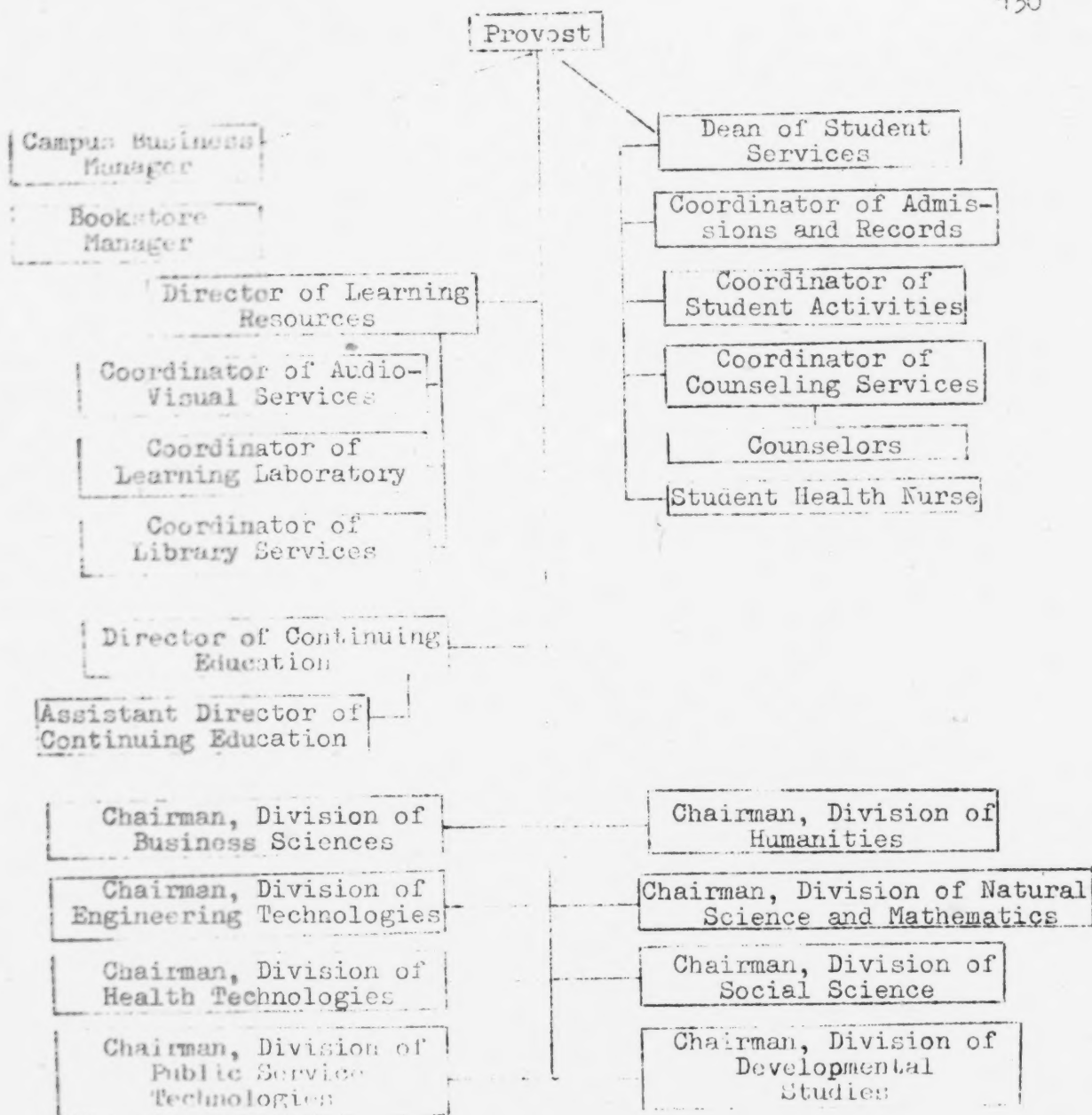
Figure 5
Organizational Chart
Virginia Community College System



Source: Faculty Handbook, Northern Virginia Community College, 1970-71, p. 9.

Figure 6

Northern Virginia Community College (College Organization)



Source: Faculty Handbook, Northern Virginia Community College, 1970-71, p. 10.

Figure 7

Northern Virginia Community College
(Campus Organization)

APPENDIX E

PROJECT IDENTIFICATION FORM GRANTING ACCESS TO THE
COMPUTER AT NORTHERN VIRGINIA COMMUNITY COLLEGE

PROJECT IDENTIFICATION FORM

132

PROJECT TITLE: A Comparative Analysis of Programmed Instruction and Convention
Instruction in Remedial Algebra.

PROJECT NUMBER: IR-71015

PROJECT LEADER: Dave Conroy

PROJECT TEAM:

J. Michael Mullen

Sherry Morica

PROJECT DESCRIPTION:

This study is being performed to analyze the effects of age and sex upon
achievement gain in programmed instruction and conventional instruction. The
results of this experiment are to be incorporated in my dissertation.

REQUESTING DEPT. OR INDIVIDUAL: Developmental Studies Division

PROJECT TIME PARAMETERS:

February 25, 1971 March 15, 1971
Begin Date Est. Completion Date Review Schedule (Weekly, Monthly, etc.)

RECOMMENDATIONS AND COMMENTS:

Recommend Approval:

Paul Taylor

PROJECT COMPLETION & ACCEPTANCE: _____
Name Date

APPENDIX F

A STATISTICAL RATIONALIZATION FOR USING THE
t-TEST FOR PAIRED SAMPLES

DERIVATION OF THE t-TEST FROM THE NORMAL z-TEST FOR
THE TEST OF EQUALITY OF MEANS FOR PAIRED SAMPLES

Normal z-test:

$$z = \frac{\bar{x} - \mu}{\sigma_{\bar{x}}} \quad (1)$$

Not knowing the mean standard deviation ($\sigma_{\bar{x}}$):

$$\sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{n}}$$

Substituting for $\sigma_{\bar{x}}$ in (1):

$$z = \frac{\bar{x} - \mu}{\sigma_x / \sqrt{n}} \quad (2)$$

Since the population standard deviation (σ_x) cannot be determined:

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^n x_i^2 - n\bar{x}^2}{n - 1}}$$

Substituting for σ_x in (2), a test other than the normal test results, since the sampling distribution of this new statistic differs from the normal distribution of the z-test. This new statistic is the t-statistic:

$$t = \frac{\bar{x} - \mu}{\sqrt{\frac{\sum_{i=1}^n x_i^2 - n\bar{x}^2}{n(n - 1)}}} \quad (3)$$

In this experiment the null hypothesis that $\mu_1 = \mu_2$ is to be tested. That is, it is assumed that the mean difference

between the pairs in the test is zero. Therefore, the mean difference ($\bar{d}$) between the pairs in a given sample is to be tested against an assumed zero difference between the population means of the pairs.

$$t = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n d_i^2 - n\bar{d}^2}{n(n-1)}}$$

APPENDIX G

THE STATISTICAL COMPUTATIONS AND DATA-BASE PAIRS FOR
EACH STATISTICAL TEST OF THE HYPOTHESES

TABLE XII

COMPLETE DATA BASE FOR PROGRAMMED INSTRUCTION

Student code	Age	Sex	Pre-test	Post-test	Gain
1P	28	M	9	27	18
2P	22	M	23	36	13
3P	24	M	16	30	14
4P	22	M	6	18	12
5P	28	F	9	20	11
6P	18	M	23	25	2
7P	18	M	16	31	15
8P	18	M	31	37	6
9P	18	F	17	29	12
10P	19	M	18	20	2
11P	40	M	11	30	19
12P	22	M	17	28	11
13P	21	M	17	27	10
14P	23	M	10	27	17
15P	28	F	5	20	15
16P	23	M	30	27	-3
17P	18	F	13	20	7
18P	21	F	10	24	14
19P	18	F	23	28	5
20P	18	F	10	20	10
21P	18	F	19	27	8
22P	33	F	14	19	5
23P	30	F	9	30	21
24P	18	F	16	21	5
25P	19	M	18	25	7
26P	34	F	15	31	16
27P	18	F	21	27	6
28P	17	F	16	23	7
29P	22	F	8	21	13
30P	34	F	8	15	7
31P	19	F	13	24	11
32P	33	F	9	26	17
33P	37	F	7	25	18
34P	18	M	21	35	14
35P	19	M	17	26	9
36P	18	M	18	24	6
37P	17	M	19	31	12
38P	25	M	19	27	8
39P	21	M	15	26	11
40P	23	M	12	10	-2
41P	18	M	22	35	13
42P	27	M	11	27	16
43P	18	M	11	25	14

TABLE X.I (continued)

Student code	Age	Sex	Pre-test	Post-test	Gain
44P	20	M	13	22	9
45P	22	M	16	27	11
46P	19	M	18	28	10
47P	18	F	19	23	4
48P	17	F	29	31	2
49P	17	F	14	18	4
50P	18	F	11	23	12
51P	18	F	15	26	11
52P	21	F	10	30	20
53P	20	M	23	30	7
54P	22	M	11	20	9
55P	24	M	17	29	12
56P	17	F	20	23	3
57P	17	F	26	28	2
58P	42	F	7	28	21
59P	18	M	14	24	10
60P	18	M	14	21	7
61P	24	M	13	20	7
62P	25	M	16	25	9
63P	22	M	3	21	18
64P	18	M	8	15	7
65P	17	M	13	14	1
66P	25	M	4	19	15
67P	18	M	15	25	10

TABLE XLII
COMPLETE DATA BASE FOR CONVENTIONAL INSTRUCTION

Student code	Age	Sex	Pre-test	Post-test	Gain
1	22	M	17	27	10
2	22	M	16	26	10
3	27	M	8	21	13
4	26	F	8	22	14
5	24	M	16	27	11
6	18	M	10	25	15
7	18	M	29	27	-2
8	24	M	8	24	16
9	17	M	11	19	8
10	19	F	10	28	18
11	18	F	18	26	8
12	20	F	13	29	16
13	17	F	21	29	8
14	30	M	11	22	11
15	18	M	12	18	6
16	23	M	20	32	12
17	23	M	22	30	8
18	20	M	11	16	5
19	18	F	14	18	4
20	18	F	12	20	8
21	18	M	18	22	4
22	17	F	4	16	12
23	30	M	7	16	9
24	18	F	9	14	5
25	18	F	22	22	0
26	18	M	24	28	4
27	19	M	10	16	6
28	17	F	11	16	5
29	18	M	21	20	-1
30	18	M	16	30	14
31	18	M	14	20	6
32	21	F	10	27	17
33	21	M	12	19	7
34	19	M	22	28	6
35	18	M	6	25	19
36	18	F	24	25	1
37	18	M	19	31	12
38	22	M	12	21	9
39	18	M	17	20	3
40	24	M	3	17	14
41	24	M	10	23	13
42	17	F	17	23	6
43	31	M	9	22	13

TABLE XIII (continued)

Student code	Age	Sex	Pre-test	Post-test	Gain
44	18	F	9	19	10
45	33	F	7	25	18
46	48	M	16	22	6
47	23	M	17	25	8
48	21	M	10	19	9
49	29	F	15	32	17
50	23	M	11	19	8
51	22	F	4	23	19
52	18	F	17	28	11
53	18	M	14	23	9
54	18	M	20	33	13
55	32	M	17	26	9
56	26	M	19	26	7
57	22	M	7	27	20
58	23	M	22	35	13
59	18	M	26	24	-2
60	22	M	24	32	8
61	19	F	10	18	8
62	22	M	15	22	7
63	17	M	19	27	8
64	25	M	17	29	12
65	23	M	17	29	12
66	17	M	24	18	-6
67	22	M	5	11	6
68	28	M	17	14	-3
69	21	F	17	24	7
70	18	F	9	19	10
71	18	F	20	31	11
72	18	M	25	36	11
73	18	M	23	30	7
74	20	M	15	27	12
75	23	M	9	27	18
76	22	M	15	16	1
77	19	M	13	22	9
78	23	F	14	29	15
79	18	F	9	22	13
80	24	M	24	32	8
81	22	M	18	20	2
82	17	F	13	33	20
83	20	M	8	22	14
84	20	M	18	27	9
85	23	M	12	30	18
86	17	M	28	31	3
87	19	M	26	25	-1
88	21	M	13	22	9

TABLE XIII (continued)

Student code	Age	Sex	Pre-test	Post-test	Gain
89	24	F	8	18	10
90	25	M	9	18	9
91	28	M	19	31	12
92	19	F	11	17	6
93	29	M	16	19	3
94	18	M	11	13	2
95	21	M	17	25	8
96	28	M	23	32	9
97	42	M	12	25	13
98	18	M	20	30	10
99	22	M	11	16	5
100	38	F	14	35	21
101	20	F	5	20	15
102	24	M	21	31	10
103	20	F	15	26	11
104	39	M	8	19	11
105	20	F	15	20	5
106	27	M	15	31	16
107	19	F	2	20	18
108	41	M	8	17	9
109	34	M	3	14	11
110	18	M	22	30	8
111	20	M	10	18	8
112	18	M	20	22	2
113	18	M	20	19	-1
114	17	M	17	26	9
115	18	M	12	25	13
116	18	F	6	19	13
117	21	M	15	26	11
118	18	F	15	23	8
119	23	M	22	31	9
120	18	M	15	25	10
121	20	M	2	8	6
122	25	M	10	25	15
123	18	F	16	14	-2
124	18	F	17	24	7
125	26	M	6	22	16
126	18	M	22	21	-1
127	18	M	20	34	14
128	18	M	16	28	12
129	22	M	14	26	12
130	18	M	19	32	13
131	24	F	17	28	11
132	20	F	23	24	1
133	19	M	16	24	8

TABLE XIII (continued)

Student code	Age	Sex	Pre-test	Post-test	Gain
134	18	F	12	19	7
135	23	M	30	30	0
136	23	M	11	25	14
137	18	F	15	32	17
138	26	M	10	27	17
139	18	F	10	26	16
140	40	F	11	27	16
141	19	M	14	28	14
142	20	F	10	18	8
143	23	M	21	27	6
144	19	M	18	14	-4
145	20	M	3	18	15
146	21	M	13	27	14
147	22	M	3	16	13
148	19	M	15	36	21
149	19	M	6	24	18
150	25	F	10	27	17
151	17	M	11	13	2
152	17	F	16	23	7
153	18	F	18	27	9
154	27	F	13	30	17
155	19	M	7	13	6
156	22	M	15	24	9
157	22	M	2	18	16
158	45	F	13	16	3
159	29	F	6	19	13
160	21	M	12	32	20
161	17	M	23	27	4
162	18	F	16	18	2
163	22	M	15	28	13
164	31	F	13	19	6
165	25	M	6	14	8
166	24	M	13	34	21
167	18	M	14	27	13
168	22	M	12	27	15
169	18	M	14	25	11
170	18	M	23	24	1
171	18	F	21	28	7
172	18	M	12	21	9
173	18	M	14	29	15
174	18	F	24	33	9
175	20	F	9	17	8
176	19	M	26	30	4
177	20	M	9	19	10
178	17	F	19	29	10
179	27	M	21	21	0

TABLE XIII (continued)

Student code	Age	Sex	Pre-test	Post-test	Gain
180	24	M	15	20	5
181	20	M	15	19	4
182	17	F	4	17	13
183	18	M	15	31	16
184	21	F	9	22	13
185	23	M	12	29	17
186	17	M	11	19	8
187	21	F	11	22	11
188	27	F	11	26	15
189	21	F	18	20	2
190	18	F	7	17	10
191	21	M	12	17	5
192	19	F	14	23	9
193	22	M	10	24	14

TABLE XIV

PAIRED DATA BASE FOR TEST OF SIGNIFICANCE OF AGE ON
ACHIEVEMENT GAIN FOR CONVENTIONAL INSTRUCTION
(Test of First Hypothesis--See Table III)

Pair		Older subject			Younger subject				
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
1	-	159	6	19	13	35	6	25	19
2	-	125	6	22	16	116	6	19	13
3	3	45	7	25	18	190	7	17	10
4	3	43	9	22	13	24	9	14	5
5	3	90	9	18	9	44	9	19	10
6	3	75	9	27	18	70	9	19	10
7	3	138	9	27	17	6	9	26	17
8	3	150	10	27	17	139	10	19	16
9	3	140	10	27	16	9	10	16	8
10	3	14	11	22	11	28	11	19	5
11	3	188	11	26	15	151	11	13	2
12	3	136	11	25	14	186	11	19	3
13	3	97	11	25	13	15	11	18	6
14	3	185	12	29	17	20	12	20	9
15	3	85	12	30	18	115	12	25	13
16	-	158	12	16	3	82	12	33	20
17	15	100	13	35	21	31	13	30	6
18	11	78	14	29	15	19	14	18	4
19	9	49	14	32	17	118	14	23	8
20	6	106	15	31	16	120	15	25	10
21	6	180	15	30	5	137	15	23	17
22	-	46	15	22	6	152	15	35	7
23	-	93	16	19	3	30	16	30	14
24	-	55	16	27	11	128	16	28	12
25	3	68	17	26	9	42	17	23	6
26	-	64	17	14	-3	114	17	26	9
27	1		17	29	12	52	17	28	11

TABLE XIV (continued)

Pair		Older subject			Younger subject				
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
28	4	131	17	28	11	124	17	24	7
29	9	65	17	29	12	39	17	20	3
30	2	91	19	31	12	178	19	29	10
31	1	56	19	26	7	63	19	27	8
32	1	16	20	32	12	71	20	31	11
33	8	179	21	31	0	13	21	29	8
34	11	102	21	31	10	29	21	20	-1
35	1	143	21	27	6	171	21	28	7
36	9	119	22	31	9	25	22	22	0
37	5	58	22	35	13	110	22	30	8
38	9	17	22	30	8	126	22	21	-1
39	5	96	23	32	9	161	23	27	4
40	14	80	24	32	8	66	24	18	-6

THE CALCULATIONS OF THE t-STATISTIC FOR PAIRED SAMPLES
 USED IN THE COMPARISON OF OLDER STUDENTS VERSUS
 YOUNGER STUDENTS IN CONVENTIONAL INSTRUCTION
 (Test of the First Hypothesis)

Formula for t-statistic using paired samples:

$$\underline{t} = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n \bar{d}_i^2 - n\bar{d}^2}{n(n-1)}}$$

Specific parameter values for the formula:

$$n=40; \bar{d}=3.175; \bar{d}^2=10.080625; n\bar{d}^2=403.225; \sum_{i=1}^n d_i^2=2573; df=39.$$

Substitution of parameters in formula and the solution:

$$\underline{t} = \frac{3.175}{\sqrt{\frac{2573-403.225}{40(39)}}$$

$$\underline{t} = \frac{3.175}{\sqrt{1.3908814}}$$

$$\underline{t} = 2.6922$$

Value of t from table given: $\alpha=.05$, $df=39$, two-tailed test.

Reject if $\underline{t} > \underline{t}_{.975}(39) = 2.021$.

Since $\underline{t} = 2.6922 > 2.021$, reject the null hypothesis.

TABLE XV

PAIRED DATA BASE FOR TEST OF SIGNIFICANCE OF AGE ON ACHIEVEMENT
GAIN FOR PROGRAMMED INSTRUCTION
(Test of Second Hypothesis--See Table IV)

Pair		Older subject				Younger subject			
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
1	0	30P	8	15	7	64P	8	15	7
2	10	52P	10	30	20	20P	10	20	10
3	7	11P	11	20	18	75P	11	25	14
4	4	42P	11	27	16	50P	11	23	12
5	8	44P	13	22	9	65P	13	14	1
6	0	61P	13	20	7	17P	13	20	7
7	1	22P	14	19	5	49P	14	18	4
8	6	26P	15	31	16	67P	15	25	10
9	2	62P	16	25	9	28P	16	23	7
10	9	3P	16	30	14	24P	16	21	5
11	0	55P	17	29	12	9P	17	29	12
12	-4	38P	19	27	8	37P	19	31	12

THE CALCULATIONS OF THE t-STATISTIC FOR PAIRED SAMPLES
 USED IN THE COMPARISON OF OLDER STUDENTS VERSUS
 YOUNGER STUDENTS IN PROGRAMMED INSTRUCTION
 (Test of the Second Hypothesis)

Formula for t-statistic using paired samples:

$$\underline{t} = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n d_i^2 - n\bar{d}^2}{n(n-1)}}$$

Specific parameter values for the formula:

$$n=12; \bar{d}=3.4166; \bar{d}^2=11.639; n\bar{d}^2=139.668; \sum_{i=1}^n d_i^2=343; df=11.$$

Substitution of parameters in formula and the solution:

$$\underline{t} = \frac{3.4166-0}{\sqrt{\frac{343 - 139.668}{12(11)}}$$

$$\underline{t} = \frac{3.4166}{\sqrt{1.54039}}$$

$$\underline{t} = 2.755$$

Value of t from table given: $\alpha=.05$, $df=11$, two tailed test.

Reject if $\underline{t} > \underline{t}_{.975}(11) = 2.201$.

Since $\underline{t} = 2.755 > 2.201$, reject the null hypothesis.

TABLE XVI

PAIRED DATA BASE FOR TEST OF SIGNIFICANCE OF SEX ON ACHIEVEMENT
GAIN FOR PROGRAMMED INSTRUCTION

(First Test of Third Hypothesis--See Table V)

Pair		Female subject			Male subject				
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
1	7	5P	9	20	11	1P	9	27	18
2	-	18P	10	24	14	14P	10	27	17
3	-	50P	11	25	12	43P	11	25	14
4	6	17P	13	20	7	65P	13	14	1
5	3	49P	14	18	4	60P	14	21	7
6	1	51P	15	26	11	67P	15	25	10
7	-10	24P	16	21	5	7P	16	31	15
8	3	9P	17	29	12	55P	17	26	9
9	4	21P	19	27	8	37P	19	31	12
10	-	27P	21	27	6	34P	21	35	14
11	3	19P	23	28	5	6P	23	25	2

THE CALCULATIONS OF THE t-STATISTIC FOR PAIRED SAMPLES
 • USED IN THE COMPARISON OF FEMALE STUDENTS VERSUS
 MALE STUDENTS IN PROGRAMMED INSTRUCTION
 (First Test of the Third Hypothesis)

Formula for t-statistic using paired samples:

$$\underline{t} = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n d_i^2 - n\bar{d}^2}{n(n-1)}}$$

Specific values to be substituted in the formula:

$$n=11; \bar{d}=-2.181; \bar{d}^2=4.7567; n\bar{d}^2=52.316; \sum_{i=1}^n d_i^2=306; df=10.$$

Substitution of parameters in the formula and the solution:

$$\underline{t} = \frac{-2.181-0}{\sqrt{\frac{306-52.316}{11(10)}}$$

$$\underline{t} = \frac{-2.181}{\sqrt{2.3062}}$$

$$\underline{t} = -1.43$$

Value of t from the table given that $\alpha=.05$, $df=10$, and two-tailed test.

Reject if $\underline{t} \leq \underline{t}_{.975}(10) = -2.228$.

Since $\underline{t} = -1.43 > -2.228$, accept the null hypothesis.

TABLE XVII

PAIRED DATA BASE FOR TEST OF SIGNIFICANCE OF SEX ON
ACHIEVEMENT GAIN FOR CONVENTIONAL INSTRUCTION

(Second Test of Third Hypothesis---See Table VI)

Pair		Female subject				Male subject			
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
1	6	116	6	19	13	35	6	25	19
2	-	159	6	19	13	125	6	22	19
3	4	190	7	17	10	155	7	13	19
4	6	89	8	18	10	8	8	24	19
5	-	4	8	22	14	3	9	21	19
6	2	175	9	17	9	177	9	19	19
7	4	139	10	26	16	6	10	25	19
8	2	61	10	18	8	27	10	16	18
9	0	142	10	18	8	111	10	18	19
10	8	32	10	27	17	48	10	23	19
11	4	150	10	27	17	41	10	19	19
12	3	28	11	16	5	9	11	19	19
13	6	92	11	17	6	186	11	16	19
14	6	187	11	22	11	18	11	22	19
15	4	188	11	26	15	14	11	22	19
16	5	20	12	20	8	115	12	25	19
17	2	134	12	19	7	172	12	22	19
18	1	82	13	33	20	77	13	22	19
19	2	12	13	29	16	88	13	22	19
20	5	19	14	18	4	31	14	20	19
21	2	192	14	23	9	141	14	28	19
22	5	118	15	33	9	120	15	31	19
23	2	137	15	32	17	183	15	27	19
24	1	105	15	20	5	74	15	19	19
25	7	103	15	26	11	181	15	31	19
26	7	49	15	32	12	106	15	31	19
27	7	152	16	23	7	30	16	30	19

TABLE XVII (continued)

Pair		Female subject			Male subject				
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
28	-14	123	16	14	-2	128	16	28	12
29	-6	162	16	18	2	133	16	24	8
30	-3	42	17	23	6	114	17	26	9
31	4	124	17	24	7	39	17	20	3
32	1	69	17	24	7	95	17	25	8
33	1	131	17	28	11	64	17	29	12
34	4	11	18	26	8	21	18	22	4
35	13	153	18	27	9	144	18	14	4
36	0	189	18	20	2	51	18	22	4
37	2	178	19	29	10	63	19	27	8
38	2	71	20	31	11	54	20	33	13
39	3	171	21	28	7	29	21	20	9
40	8	25	22	22	0	110	22	30	8
41	5	36	24	35	11	66	24	18	6
42	5	174	24	33	9	26	24	28	4

THE CALCULATIONS OF THE t -STATISTIC FOR PAIRED SAMPLES
 USED IN THE COMPARISON OF FEMALE STUDENTS VERSUS
 MALE STUDENTS IN CONVENTIONAL INSTRUCTION
 (Second Test of the Third Hypothesis)

Formula for t -statistic using paired samples:

$$\underline{t} = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n d_i^2 - n\bar{d}^2}{n(n-1)}}$$

Specific parameter values to be substituted in the formula:

$$n=42; \bar{d}=.3095; \bar{d}^2=.09579; n\bar{d}^2=4.02318; \sum_{i=1}^n d_i^2=1287; df=41.$$

Substitution of parameters in the formula and the solution:

$$\underline{t} = \frac{.3095-0}{\sqrt{\frac{1287-4.02318}{(42)(41)}}$$

$$\underline{t} = \frac{.3095}{\sqrt{.74505}}$$

$$\underline{t} = .358$$

Value of $\underline{t}$ from the table given that $\alpha=.05$, $df=41$, and two-tailed test.

Reject if $\underline{t} > t_{.975}(41) = 2.021$.

Since $\underline{t} = .358 < 2.021$, accept the null hypothesis.

TABLE XVIII

PAIRED DATA BASE FOR TEST OF SIGNIFICANCE OF SEX ON ACHIEVEMENT GAIN FOR
MALE STUDENTS IN CONVENTIONAL INSTRUCTION VERSUS FEMALE STUDENTS IN
PROGRAMMED INSTRUCTION

(Third Test of Third Hypothesis--See Table VII)

Pair		Female subject Programmed instruction				Male subject Conventional instruction			
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
1	-	29P	8	21	13	83	9	22	14
2	-	32P	9	26	17	43	9	22	13
3	-	20P	10	20	10	6	10	25	15
4	-	18P	10	24	14	48	10	19	9
5	10	50P	11	23	12	151	11	13	2
6	2	31P	13	24	11	77	13	22	9
7	-	49P	14	18	4	31	14	20	6
8	-	51P	15	26	11	120	15	25	10
9	-	28P	16	23	7	30	16	30	14
10	-	24P	16	21	5	128	16	28	12
11	-	9P	17	29	12	39	17	20	3
12	-	47P	19	25	4	37	19	31	12
13	-	21P	19	23	8	130	19	32	13
14	-	56P	20	23	3	112	20	22	2
15	1	27P	21	27	6	29	21	20	-1
16	2	19P	23	28	5	73	23	30	7
17	4	48P	29	31	2	7	29	27	-2

THE CALCULATIONS OF THE t -STATISTIC FOR PAIRED SAMPLES
 USED IN THE COMPARISON OF FEMALE STUDENTS IN
 PROGRAMMED INSTRUCTION VERSUS MALE STUDENTS
 IN CONVENTIONAL INSTRUCTION
 (Third Test of the Third Hypothesis)

Formula for t -statistic using paired samples:

$$\underline{t} = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n d_i^2 - n\bar{d}^2}{n(n-1)}}$$

Specific parameter values to be substituted in the formula:

$$n=17; \bar{d}=.353; \bar{d}^2=.1246; n\bar{d}^2=2.1182; \sum_{i=1}^n d_i^2=514; df=16.$$

Substitution of parameters in the formula and the solution:

$$\underline{t} = \frac{.353-0}{\sqrt{\frac{514-2.1182}{17(16)}}$$

$$\underline{t} = \frac{.353}{\sqrt{511.8818}}$$

$$\underline{t} = .0156$$

Value of $\underline{t}$ from the table given that $\alpha=.05$, $df=16$, and two-tailed test.

Reject if $\underline{t} > \underline{t}_{.975}(16)=2.120$.

Since $\underline{t} = .0156 < 2.120$, accept the null hypothesis.

TABLE XIX

PAIRED DATA BASE FOR TEST OF SIGNIFICANCE OF SEX ON ACHIEVEMENT GAIN FOR
MALE STUDENTS IN PROGRAMMED INSTRUCTION VERSUS FEMALE STUDENTS IN
CONVENTIONAL INSTRUCTION

(Fourth Test of Third Hypothesis--See Table VIII)

Pair		Female subject Conventional instruction			Male subject Programmed instruction				
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
1	0	150	10	27	17	14P	10	27	17
2	-	28	11	16	5	43P	11	25	14
3	2	187	11	22	11	54P	11	20	9
4	-	188	11	26	15	42P	11	27	16
5	3	140	11	27	16	41P	11	30	19
6	19	82	13	33	20	65P	13	14	1
7	8	154	13	30	17	44P	13	22	9
8	3	19	14	18	4	60P	14	21	7
9	-	192	14	23	9	59P	14	24	10
10	2	118	15	23	8	67P	15	25	10
11	6	105	15	20	5	39P	15	26	11
12	-	123	16	14	-2	7P	16	31	15
13	2	52	17	28	11	35P	17	26	9
14	3	69	17	24	7	13P	17	27	10
15	1	131	17	28	11	55P	17	29	12
16	2	11	18	26	8	36P	18	24	6
17	1	153	18	27	9	46P	18	28	10
18	2	178	19	29	10	37P	19	31	12
19	7	171	21	26	7	34P	21	35	14
20	-	25	22	22	0	41P	22	35	13
21	6	132	23	24	1	53P	23	30	7

THE CALCULATIONS OF THE t -STATISTIC FOR PAIRED SAMPLES
USED IN THE COMPARISON OF FEMALE STUDENTS IN
CONVENTIONAL INSTRUCTION VERSUS MALE STUDENTS
IN PROGRAMMED INSTRUCTION
(Fourth Test of the Third Hypothesis)

Formula for t -statistic using paired samples:

$$\underline{t} = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n d_i^2 - n\bar{d}^2}{n(n-1)}}$$

Specific parameter values to be substituted in the formula:

$$n=21; \bar{d}=2; \bar{d}^2=4; n\bar{d}^2=84; \sum_{i=1}^n d_i^2=1136; df=20.$$

Substitution of parameters in the formula and the solution:

$$\underline{t} = \frac{2 - 0}{\sqrt{\frac{1136 - 84}{21(20)}}$$

$$\underline{t} = \frac{2}{\sqrt{2.504}}$$

$$\underline{t} = 1.26$$

Value of $\underline{t}$ from the table given that $\alpha=.05$, $df=20$, and two-tailed test.

Reject if $\underline{t} > \underline{t}_{.975}(20)=2.086$.

Since $\underline{t} = 1.26 < 2.086$, accept the null hypothesis.

TABLE XX

PAIRED DATA BASE FOR TEST OF SIGNIFICANCE OF ACHIEVEMENT GAIN WHEN TEACHING
 REMEDIAL ALGEBRA I BY PROGRAMED INSTRUCTION AND BY CONVENTIONAL
 INSTRUCTION WHILE HOLDING VARIABLES OF PRE-TEST SCORE,
 AGE, AND SEX CONSTANT

(Test of Fourth Hypothesis--See Table IX)

Pair		Subject in programmed instruction				Subject in conventional instruction			
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
1	5	63P	3	21	18	147	3	16	13
2	0	15P	5	20	15	101	5	20	15
3	-	20P	10	20	10	139	10	26	16
4	-	18P	10	24	14	32	10	25	15
5	2	14P	10	27	17	122	10	19	9
6	6	43P	11	25	14	186	11	17	6
7	6	50P	11	23	12	92	11	16	5
8	4	54P	11	20	9	99	11	22	11
9	5	42P	11	27	16	14	11	30	18
10	-20	40P	12	10	-2	85	12	22	9
11	8	65P	13	14	1	77	13	33	20
12	-13	17P	13	20	7	82	13	34	21
13	-14	61P	13	20	7	166	13	30	17
14	-	44P	13	22	9	154	13	18	4
15	0	49P	14	18	4	19	14	20	6
16	1	60P	14	21	7	31	14	23	9
17	1	59P	14	24	10	53	15	25	10
18	0	67P	15	25	10	120	15	23	8
19	3	51P	15	26	11	118	15	26	11
20	0	39P	15	26	11	117	15	23	7
21	0	28P	16	23	7	152	16	14	2
22	7	24P	16	21	5	123	16	30	-14
23	1	7P	16	31	15	30	16	26	10
24	1	45P	16	27	11	2	16		

TABLE XX (continued)

Pair		Subject in programmed instruction				Subject in conventional instruction			
Number	Difference in gain	Student code	Pre-test	Post-test	Gain	Student code	Pre-test	Post-test	Gain
25	5	3P	16	30	14	5	16	27	11
26	1	9P	17	29	12	52	17	28	11
27	6	35P	17	26	9	39	17	20	3
28	2	13P	17	27	10	95	17	25	8
29	1	12P	17	28	11	1	17	27	10
30	0	55P	17	29	12	65	17	29	12
31	3	36P	18	24	6	21	17	22	4
32	0	10P	18	20	2	44	18	14	4
33	4	37P	19	31	12	63	19	27	8
34	3	47P	19	23	4	178	19	29	10
35	8	56P	20	23	3	71	20	31	11
36	1	27P	21	27	6	171	21	28	7
37	15	34P	21	35	14	29	21	20	1
38	5	41P	22	35	13	110	21	30	8
39	5	6P	23	25	2	73	22	30	7
40	4	57P	26	28	2	59	23	24	2
41	3	16P	30	27	-3	135	30	30	0

THE CALCULATIONS OF THE t -STATISTIC FOR PAIRED SAMPLES
 USED IN THE COMPARISON OF PROGRAMED INSTRUCTION
 VERSUS CONVENTIONAL INSTRUCTION BASED UPON THE
 VARIABLES OF PRE-TEST SCORE, AGE, AND SEX
 (Test of the Fourth Hypothesis)

Formula for t -statistic using paired samples:

$$t = \frac{\bar{d} - 0}{\sqrt{\frac{\sum_{i=1}^n d_i^2 - n\bar{d}^2}{n(n-1)}}$$

Specific parameter values to be substituted in the formula:

$$n=41; \bar{d}=-.0975; \bar{d}^2=.0095; n\bar{d}^2=.3895; \sum_{i=1}^n d_i^2=1650; df=40.$$

Substitution of parameters in the formula and the solution:

$$t = \frac{-.0975 - 0}{\sqrt{\frac{1650 - .3895}{41(40)}}$$

$$t = \frac{-.0975}{\sqrt{1.0058}}$$

$$t = -0.09735$$

Value of t from the table given that $\alpha=.05$, $df=40$, and two-tailed test.

Reject if $t < t_{.975}(40) = -2.021$.

Since $t = -0.09735 > -2.021$, accept the null hypothesis.